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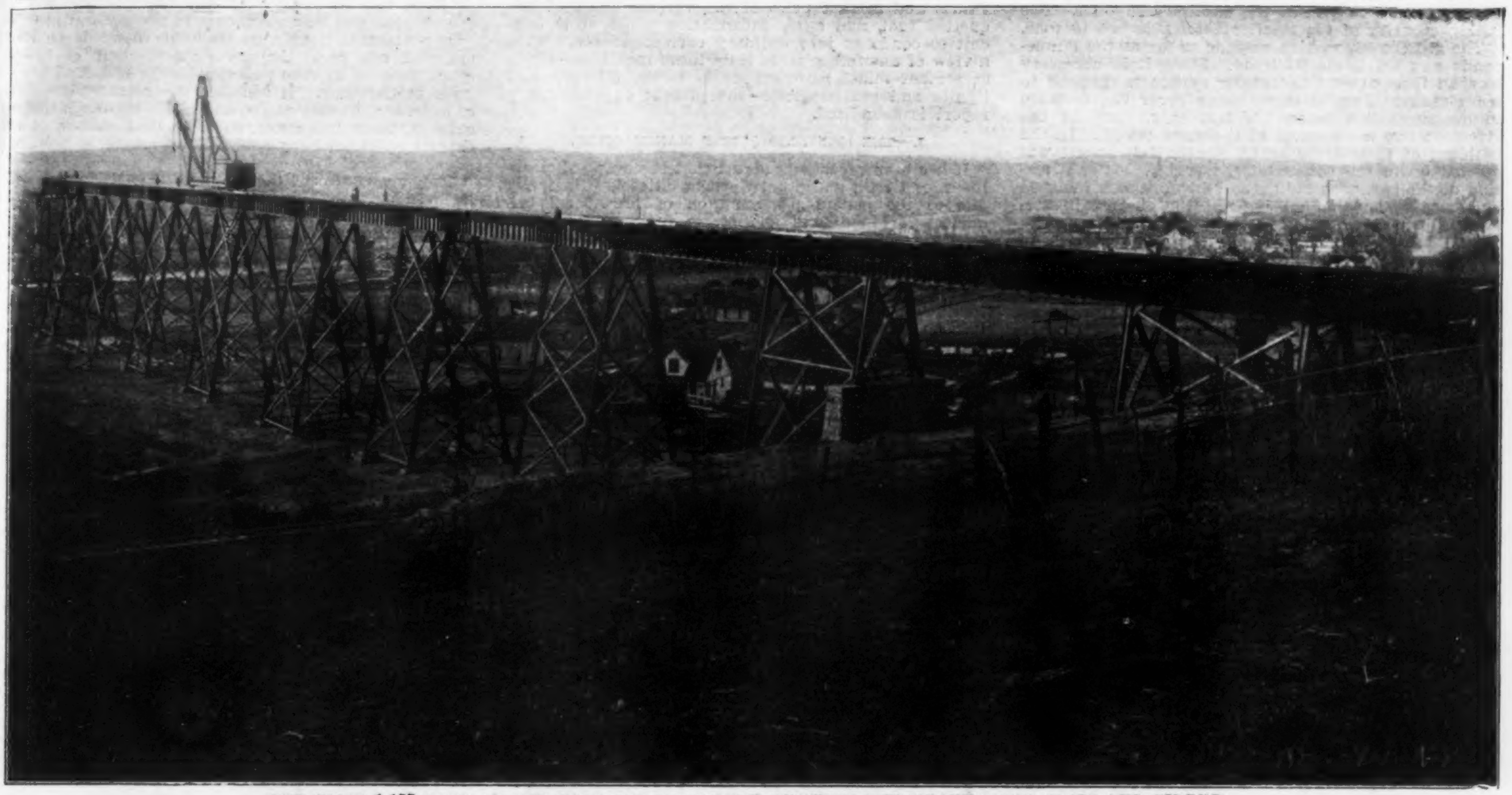


THE FIRST 1,155 FEET OF THE FORT DODGE VIADUCT, SHOWING THE HEAVY STEEL POSTS AND GIRDERS.

THE FIRST AND SECOND TRUSS-SPANS OF THE FORT DODGE VIADUCT, SHOWING THE WOODWORK SUPPORTED BY PILES.

THE GREAT VIADUCT AT FORT DODGE, IOWA.

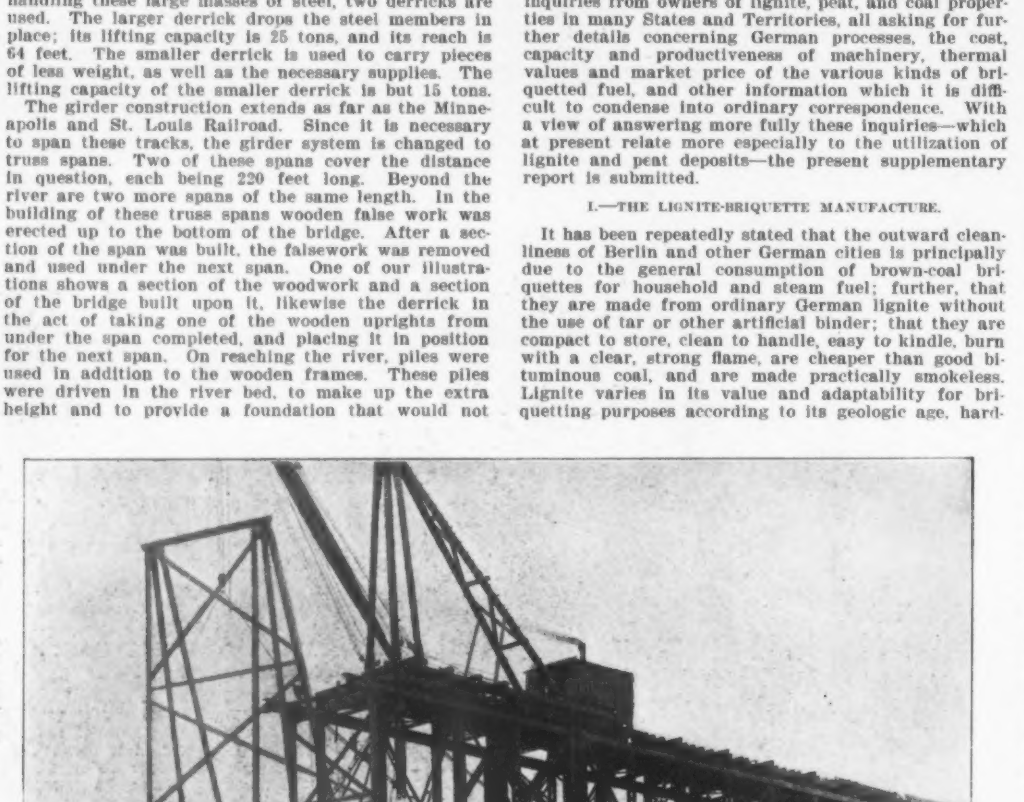
THE VIADUCT AT FORT DODGE, IOWA.*

By Bruno Schroeder.

Fort Dodge, Iowa, will soon be able to boast of a noteworthy engineering structure in the shape of a bridge which is to cross the Des Moines River Valley. The viaduct is an extension of the Chicago Great Western Railroad. Its length is 2,582 feet. Its maximum height is 134 feet. The dimensions of the structure are slightly smaller than the Boone Bridge.

The first 1,155 feet of the viaduct are built of heavy steel uprights or posts, of which the highest is 104 feet from the ground. On these uprights, steel girders rest, the longest of which measures 75 feet and weighs about 18 tons. The smaller girders rest on the towers, and are 38 feet long. For the purpose of handling these large masses of steel, two derricks are used. The larger derrick drops the steel members in place; its lifting capacity is 25 tons, and its reach is 64 feet. The smaller derrick is used to carry pieces of less weight, as well as the necessary supplies. The lifting capacity of the smaller derrick is but 15 tons.

The girder construction extends as far as the Minneapolis and St. Louis Railroad. Since it is necessary to span these tracks, the girder system is changed to truss spans. Two of these spans cover the distance in question, each being 220 feet long. Beyond the river are two more spans of the same length. In the building of these truss spans wooden false work was erected up to the bottom of the bridge. After a section of the span was built, the falsework was removed and used under the next span. One of our illustrations shows a section of the woodwork and a section of the bridge built upon it, likewise the derrick in the act of taking one of the wooden uprights from under the span completed, and placing it in position for the next span. On reaching the river, piles were used in addition to the wooden frames. These piles were driven in the river bed, to make up the extra height and to provide a foundation that would not wash away. Fortunately at this point the river was shallow, so that the work was not difficult. Beyond the river girders are again used, the width of the girders here being 10 feet from center to center. The uprights have a slant of 4 inches to the foot. There is room for only one track.



THE FIRST SECTION OF THE WOODWORK, THE FIRST SECTION OF THE BRIDGE BUILT UPON IT, AND THE DERRICK IN THE ACT OF TAKING ONE OF THE WOODEN UPRIGHTS FROM UNDER THE SPAN COMPLETED AND OF PLACING IT IN POSITION FOR THE NEXT SPAN.

In laying the foundation, bolts were placed in each pier extending down several feet. It was, therefore, necessary to place these bolts after the foundation was laid. Upon these bolts the posts by which the girders are held rest. The distance between posts varies from 38 to 220 feet. Although the piers and bolts were made by one company and the steel work by another, still there was not a variation of a quarter of an inch. A more striking example of the precision of modern engineering could hardly be desired.

The weight of the bridge is estimated at 3,300 tons. From twelve to sixteen men were employed in assembling the steel work. The entire number of men employed in constructing the bridge was about fifty.

* Specially prepared for the Scientific American Supplement.

LIGNITE, PEAT, AND COAL-DUST FUEL.

Since the publication of the last report of this series (Advance Sheets No. 1527, December 23, 1902) on the methods of manufacturing fuel briquettes from coal dust, lignite, and peat in Germany, two experienced engineers—one from New York, the other from Minnesota—have come to this country to make careful scientific studies of the subject for the purpose of assisting to transplant the industry, or such of it as may be adaptable to American conditions, to the United States. Both these experts have declared themselves astonished by the proportions of the fuel-briquette manufacture in Germany, the size and number of factories engaged, the amount of capital invested, the technical excellence of machinery employed, the permanent fireproof buildings, and the modernized methods of handling materials and product. One of them said:

"Of all this, we have at home not the faintest conception. We read in a consular report that there are in this country 286 brown-coal briquette factories with 691 presses; that they work up annually 44,211,000 tons of lignite; and that the 21 coal-dust-briquette factories of the Dortmund Syndicate alone turn out 2,100,000 tons of 'industry briquettes' per annum, but such figures leave no definite impression. We haven't got beyond the stage where a more or less experimental machine press under a wooden shed is considered a briquette factory."

Meanwhile, each American mail continues to bring inquiries from owners of lignite, peat, and coal properties in many States and Territories, all asking for further details concerning German processes, the cost, capacity and productiveness of machinery, thermal values and market price of the various kinds of briquetted fuel, and other information which it is difficult to condense into ordinary correspondence. With a view of answering more fully these inquiries—which at present relate more especially to the utilization of lignite and peat deposits—the present supplementary report is submitted.

I.—THE LIGNITE-BRIQUETTE MANUFACTURE.

It has been repeatedly stated that the outward cleanliness of Berlin and other German cities is principally due to the general consumption of brown-coal briquettes for household and steam fuel; further, that they are made from ordinary German lignite without the use of tar or other artificial binder; that they are compact to store, clean to handle, easy to kindle, burn with a clear, strong flame, are cheaper than good bituminous coal, and are made practically smokeless. Lignite varies in its value and adaptability for briquetting purposes according to its geologic age, hardness, and the percentage of water contained. A lignite with less than 30 per cent of water is very difficult to work by the usual processes, and it is for this reason that Austria-Hungary, which has an abundance of very old and hard brown coal that contains from 26 to 28 per cent of moisture, has practically no supply of briquettes from that source. German lignite, on the other hand, is of much more recent formation; it contains from 46 to 52 per cent of water, and is usually so soft that it can be cut with a spade. Many lignite beds in this country are filled with logs and pieces of wood, so well preserved in the matrix of partially carbonized material that they burn readily and form a cheap and abundant fuel for steam and other heating at the briquette factories. The part played by the water contained in lignite forms the key to the whole economic briquetting process. The crude brown coal is brought from the mine, crushed and pulverized, and then run through a large revolving tubular cylinder, heated by exhaust steam from the driving engine, and hung on an inclined plane so that the powdered material runs downward through the tubes by gravity, and is carried into the machine press that stamps it into briquettes. During this passage through the cylinder, it is dried and heated until there remains the right proportion of moisture, combined with the proper temperature to develop the latent bitumen in the lignite and make the powdered mass plastic and easy to mold under heavy pressure between heated iron jaws into a hard, clean briquette, with a glistening surface and sufficient firmness of structure to stand weather, transportation, and other contingencies. To do this perfectly and economically, the natural lignite should contain, as it comes from the mine, approximately enough water so that heating to the proper temperature for pressing will evaporate out just sufficient water to leave it at the proper degree of moisture. The ideal proportion is about 45 per cent of water, so that German lignite contains rather too much, while Austrian contains much too little, though this latter difficulty has lately been partially overcome by steaming. The important question to be now decided is how American lignite will fulfill these requirements.

During the past six weeks, samples of lignite from near Bismarck, N. Dak., and from Troy, Ala., have been received at this consulate, turned over to the syndicate mentioned in a previous report,* and molded experimentally into briquettes with entire success. The Dakota lignite is old and hard, contains 38 per cent of water, but crushes and pulverizes easily and forms without binder briquettes of firm structure, which burn readily, are practically smokeless, and leave only 4 per cent of ash, while the best German brown-coal briquettes yield from 9 to 12 per cent of inorganic residue. The percentage of water contained is rather low, but by adapting the heating-drying process to that proportion of moisture, this obstacle, such as it is, can be easily met, and the reduced task of evaporation will be an economy in the general process.

The Alabama lignite, on the other hand, is an ideal material, and from the one sample submitted is conceded here to be even superior to the standard brown coals of Germany. It contains the correct percentage of moisture, crushes easily, and molds readily into firm, shining, black briquettes, so clean that, as one of the experts at Magdeburg said, "They might be used for paper weights."

The importance of these simple demonstrations will be inferred from the fact that, according to a recent State geological report, there are 55,000 square miles of lignite beds in the Dakotas and Montana, all near the surface of the ground, and ranging in thickness from 20 to 80 feet. The extent of the lignite deposits in the Gulf States is perhaps less exactly known, but they certainly cover a large area. There is also lignite in Missouri, Iowa, and several other Western States and Territories, and it is from all those hitherto practically neglected deposits that an inexhaustible future supply of smokeless domestic fuel will be derived. It will, therefore, be of interest to state concisely what constitutes a first-class, up-to-date lignite-briquette factory in Germany, where the industry has reached, after many years' experience, its highest development. A typical example is the factory at Lauchhammer, about 80 miles south of Berlin, on the direct line to Dresden. This establishment, which is of the latest and most approved construction, has eight presses, with the necessary pulverizing, heating, and drying plant, run by electric motors with current generated by steam evaporated with wood from the mines, the whole under handsome, substantial buildings of brick, stone, and iron; and cost, with tracks, switches, and full equipment for handling raw material and loading the briquettes into cars, $371,000, of which $178,500 was paid for machinery. Each press weighs 32 metric tons and stamps out 100 to 120 briquettes per minute, or 70 tons in a double-turn day's work of twenty hours. The heating and drying apparatus for each press weighs 18 tons. The power required for each press and dryer is 125 horse power, and both the dryer and jaws of the press between which the briquettes are squeezed at enormous pressure are heated by exhaust steam from the Corliss engine in the power house, the whole supply for the eight machines being equivalent to about 150 horse power.

Thus equipped, the plant at Lauchhammer turns out from 500 to 600 tons of briquettes per day, which sell on cars at the factory for from 7 to 9 marks ($1.66 to $2.14), according to season and market, with an average of 8 marks ($1.90) per 1,000 kilogrammes, or metric ton of 2,204 pounds. Profits depend on the usual varying conditions, location, management, demands, etc., but it is common to read in the Berlin papers official notices announcing dividends of brown-coal-briquette companies ranging from 15 to 20 per cent of their capital. So enormously has the industry been developed in recent years that there is now an overproduction, and it is said that 100,000 carloads (1,000,000 tons) of briquettes will be carried over to the fuel supply of next summer and autumn.

II.—THE UTILIZATION OF PEAT.

Peat as a material for fuel ranks next in natural order below lignite, in that it is of similar but much more recent geologic origin, contains more water, is but slightly carbonized, and has a correspondingly lower thermal value than brown coal. The task of converting peat into serviceable fuel consists in cleaning the material of roots and rubbish, reducing the water to a small percentage, and so condensing the peat in volume that its thermal value shall be raised to practical efficiency. This is done by various methods, some of which are in this country as yet partially covered by patents, but they may all be grouped under three heads, according to the form which the ultimate product is to assume, viz: (1) Compressed peat, with or without admixture of coal dust or other inflammable matter; (2) peat coke; and (3) briquettes made by compression, with or without heat, of the material prepared by the first of these processes.

Compressed peat.

A pioneer in the invention of machinery and processes for making compressed peat in northern Europe appears to have been Mr. C. Schlickeysen, of Rixdorf, near Berlin, whose installation and present methods have been mentioned in a previous report of this series.† His first two machines were of vertical construction, and were built in 1859 for a steam peat-compressing plant at Zintenhof, near Riga, in Russia, where they worked successfully for many years, turning out daily about 80,000 pieces of wet compressed peat, which, after drying, were used as smokeless fuel in a large cloth factory at that place. During the ensuing forty years, he has built peat-compressing plants in Holland, Hungary, Switzerland, and at various places in Germany, constantly improving his equipment and processes with a view of perfecting the product, cheapening its cost, and substituting more and more automatic machinery for manual labor, until the

* Advance Sheets No. 1527 (December 23, 1902).
† Advance Sheets No. 1466 (October 11, 1902).

system so evolved may be accepted as standard in this country.

Raw peat, as it comes from the bog, contains about 85 per cent water, 13 per cent combustible material, and 2 per cent inorganic matter. To obtain the 13 per cent of combustible elements in the cheapest, most direct manner, the peat is cut with spades, and shoveled into the trough of a long, sloping belt-and-bucket elevator, which carries it up and drops it into a machine which cuts, tears, kneads, and mixes it to uniform consistency, in which state it passes downward and is forced out by a horizontal screw into long, plastic skeins about 3 by 4 inches in transverse section; these are delivered at the tail of the machine on boards 2 feet long, which are lifted off by hand when filled, laid on tram cars, and run out to a cleared space, where they are laid in rows on the ground, and the skeins cut with a knife into bricks or sections 10 inches long, which, being left to dry, lose by exposure in ordinary weather one-half their water contents in a period of two weeks. The peat loses by this machine process one-third its bulk, so that a machine which works 21 cubic meters* of raw turf per hour delivers 14 cubic meters of clean peat or 7,000 wet bricks of the size indicated, which contain from 3 to 4 tons of dry compressed peat in a condition to be used as fuel. A plant of this kind includes, besides the elevator and grinding press, a 10-horse power portable engine, which is fired with peat refuse, and cars and tracks for handling the material. The whole plant is movable, is taken bodily to the bog, set up at the farther edge of the moor to be worked, and moved backward as the peat bed is excavated and exhausted. An important recent improvement by Mr. Schlickeysen is an excavating machine, which in moors reasonably free from logs and stones digs and elevates peat with great rapidity, thus saving the hard, wet, unhealthy work of several men. The cost of such a plant, complete, with engine, tracks, cars, etc., ready to operate, is 18,620 marks ($4,431), and its operation, when used without machine digger, employs 17 men besides engineer and fireman, a total cost for labor in North Germany of 120 marks ($28.56) per day. After air-drying on the ground until their water contents are reduced to 38 or 40 per cent, the peat blocks are built up in open formation, like bricks in a kiln, to dry until the water is reduced to 15 to 18 per cent, when they become a fuel with a thermal value of 3,000 to 4,000 calories. This value may be increased by converting the air-dried peat into briquettes, which is done by heavy pressure with heat in a machine press specially constructed for the purpose.

One of the important improvements of recent years has been attained by mixing the peat pulp, as it passes through the grinding machine, with other inflammable materials, viz., bituminous-coal dust or slack up to 30 per cent, anthracite culm to 40 per cent, or dry sawdust to 15 per cent. These dry, pulverized materials, when mingled with the wet peat, not only greatly enhance its subsequent value as fuel, but facilitate the drying process and render it tough, dense, elastic, and capable of being pressed cold into salon briquettes of high quality.

There are in the State of New Jersey, within easy distance of the coast, extensive peat beds which have not hitherto been utilized. There are at the terminal coal yards in Jersey City and Hoboken large quantities of coal dust, both anthracite and bituminous, that are treated as waste. May not the neglected peat and the worthless dust of the coal yards be combined by processes already perfected and successful here into a clean, cheap, and effective fuel for household purposes?

Peat-coke and secondary products.

But by far the most modern, scientific, and rational method of utilizing peat appears to be that of converting it into coke, by carbonizing in retort ovens with recovery of the gas, tar, and other by-products of distillation. This has been the subject of many years' study and experiment in Germany, the best results of which have been embodied in the system perfected and patented by Martin Ziegler, a chemical engineer of high reputation, which gives to the manufacture of peat coke the dignity of a perfected industrial process. Concisely stated, the Ziegler method consists in carbonizing peat in closed ovens, heated by burning them under the gases generated by the coking process itself. Such a plant is therefore self-sustaining, the only fuel required being coal or wood sufficient to heat the ovens for the first charge, when the gases generated by the coking process become available and enable the operation to be repeated and continued indefinitely. Not only this, but the off-heat from the retort furnaces passes on and heats the drying chambers in which the raw, wet peat is prepared for the ovens by drying to the point of economical carbonization. There is transmitted to the Department as an exhibit with this report a sample† of 1 kilogramme (1,000 grammes, or 2.2 pounds) of raw peat and the several products derived therefrom by the Ziegler process, each in its due proportion, as follows: Three hundred and fifty grammes of coke, 40 grammes of tar, and 400 grammes of gas liquor, from which last is derived 6 grammes of methyl alcohol, 6 grammes of acetate of lime, and 4 grammes of sulphate of ammonia. If this sample be multiplied a thousandfold to a metric ton, and the value of each product given at its present market price in Germany, the demonstration would be as follows:

Description.	Value. Marks.	
1 ton (1,000 kilogrammes) of peat, costing, dried, 5 marks ($1.19), produces:		
350 kilogrammes (771.6 pounds) of peat coke	15.75	$3.75
40 kilogrammes (88.2 pounds) of tar	2.20	.52
6 kilogrammes (13.2 pounds) of methyl alcohol	4.20	1.00
6 kilogrammes (13.2 pounds) of acetate of lime	.72	.17
4 kilogrammes (8.8 pounds) of sulphate of ammonia	.88	.21
Total	23.75	$5.65

The peat coke produced as the primary product of this process is jet black, resonant, firm, and columnal in structure, pure as charcoal from phosphorus or sulphur, and, having a thermal value of from 6,776 to 7,042 calories, it is so highly prized as a fuel for smelting foundry iron, copper refining, and other metallurgical purposes that it readily commands from 40 to 50 marks ($9.52 to $11.90) per ton. It is also a high-class fuel for smelting iron ores, but as the process is comparatively new and the output limited, it is as yet too scarce and expensive for blast-furnace purposes. Crushed and graded to chestnut size, it forms an excellent substitute for anthracite in base-burning stoves. In larger lumps, as it comes from the oven, it fulfills substantially all the various uses of wood charcoal as a clean, smokeless fuel. The cost of a four-oven plant, with all apparatus for cutting and drying the peat, distilling the gas liquor, and extracting paraffin from tar, is given at $95,200. Such a plant is reckoned capable of working up annually 15,000 tons of peat, the various products of which would sell, at present wholesale-market prices, for 494,100 marks ($117,596). A plant of 12 ovens, with all appurtenances complete, would cost $261,800 in Germany, and should produce annually products worth $350,000, from which, deducting the carefully estimated cost of peat, labor, depreciation of property, and other expenses—$179,200—there would remain a profit on the year's operation of $170,800. This process is in successful operation at Redkino, in Russia, and the German government has evinced its practical interest in the subject by placing at the disposal of the company a large tract of peat-moor lands, the property of the State, on which extensive works will be erected during the coming year.

III.—COAL-DUST BRIQUETTES.

While Germany is pre-eminent in the scientific utilization of lignite and peat as materials for prepared fuel, it is not apparent that this technical superiority is so absolute in the treatment of coal dust. It is true that the coal-briquette manufacture is fully organized and developed in this country, that there are several German builders of coal-briquetting machinery who are masters of that branch of construction, but the same is true of France, Belgium, and England, where the conversion of coal waste into briquettes for locomotive and other steam fuel, as well as for grates and heating stoves, has long been a standard and established industry. It is not known that it has anywhere been found possible to make a marketable briquette of bituminous or anthracite coal dust without the use of a matrix or binder to hold the pulverized material together. The percentage of binder required varies with the composition of the coal, from 2 to 10 per cent, and, as has been previously explained, the pitch of coal tar, which is the binder ordinarily used, costs in Germany from $10 to $12 per ton, and at that price its use for briquetting purposes in a higher proportion than 6 to 7 per cent is commercially unprofitable.

The ingenuity of inventors in European countries has of late years been directed especially toward improvements in binders and the discovery of materials other than coal tar which would answer the same purpose. One hears and reads from time to time of a new matrix which will cheapen the cost of coal briquettes, facilitate their manufacture, or improve their quality; but these accounts are founded rather on the claims of inventors and promoters than on demonstrated industrial results. One of the latest and most interesting of these discoveries is reported from England, where it is stated that Messrs. William Johnson & Sons, makers of briquette machinery at Leeds, have in use a binder produced by an inventor named Cory, which, when used with Cardiff coal, produces industrial briquettes which are practically smokeless. This fuel is under trial by the British Admiralty, and a photograph has been published showing two war vessels steaming side by side—one burning raw Cardiff coal, with volumes of dense smoke trailing from its chimneys; the other using Cardiff briquettes made by the Cory process, leaving an aërial wake as clear as though the furnaces were stoked with charcoal or anthracite. So far as appears, this process does not claim to use the inferior waste of mines or coal yards, but takes good coal, condenses and renders it compact to transport and, to all practical purposes, smokeless. It is further stated that a machine costing $4,500 will produce 50 tons of briquettes per day, and plans are matured by which one or more of them will be exhibited in operation during the coming exposition at St. Louis.—Frank H. Mason, Consul-General at Berlin.

THE FIRST SECTION OF THE VIADUCT.

THE VALUE OF RATIONAL METHODS IN COKE PRODUCTION.

NOTWITHSTANDING all that has been written and said on the subject, and despite the several convincing object lessons which are now in operation in the United States to show the economic value of the retort oven in coke manufacture, an overwhelming percentage of American coke is still made in the primitive "beehive," or open-mouthed, ovens, by which the volatile elements of the coal—averaging, roughly, 40 per cent of its value—are poured out as waste to blacken and defile the surrounding country.

Germany adopted, many years ago, a more rational and economical system, and it was largely through the saving thus achieved that German iron and steel was enabled to invade the British and other foreign markets. From some statistics furnished by the German Tar-Selling Syndicate—an association of coal and coke operators organized for the uniform sale of the secondary products of coke manufacture—the following facts are derived, which throw an interesting light upon the cash value of a rational scientific system of coke production. It should be remembered that much of the soft coal of Germany is of a "lean" grade, so poor in volatile elements that the use of expensive retort ovens for coking it would not be justified.

But from the report above cited, it appears that the firms and companies included in the syndicate produced coke in 1901 as follows:

	Tons.
In the Ruhr district (Westphalia)	10,000,000
In Silesia and Saxony	1,820,000
In Aix and Saar districts	1,200,000
Total	13,020,000

Of this whole amount, 6,900,000 tons of coke, or slightly more than one-half, was made in retort ovens, almost all of the Otto-Hoffman type, which, besides saving the gas generated by the coking process, recovered other secondary products which were valued as follows:

Tar	$1,237,600
Sulphate of ammonia	4,247,300
Benzole	1,175,720
Total	$6,660,620

Reckoning the value of the 6,900,000 tons of coke thus produced at 13 marks ($3.09) per ton, which was the mean average rate for blast-furnace coke during the year under consideration, we have the following interesting exhibit: Six million nine hundred thousand tons of coke valued at $21,321,000; tar, ammonia, and benzole derived therefrom, $6,660,620.

Unfortunately, there are no exact statistics from which the value of the gas saved by the retort ovens and used for steaming, heating, and illuminating purposes can be derived, but it would be a conservative estimate to assume that the gas was worth at least one-fourth as much as the coke, and that the aggregate value of all secondary products—gas, tar, ammonia, and benzole—was not less, but rather more, than one-half that of the coke, which under the "beehive" system is the sole marketable product obtained. A process of manufacture which not only renders a coking plant as clean and free from smoke as an ordinary factory, but adds 50 per cent to the value of its products, would seem worthy of general adoption even in a country of such vast and cheap resources as the United States.

* 1 cubic meter = 35.316 cubic feet.

† Filed in the Bureau of Foreign Commerce, where it may be examined by parties interested.

[Continued from SUPPLEMENT No. 1425, page 22833.]

THE DEVELOPMENT OF MARCONI'S SYSTEM OF WIRELESS TELEGRAPHY.*

By EMILE GUARINI.

AFTER the Bristol experiments, Marconi's system developed through five stages which are worthy of some attention, because they mark distinct periods in the

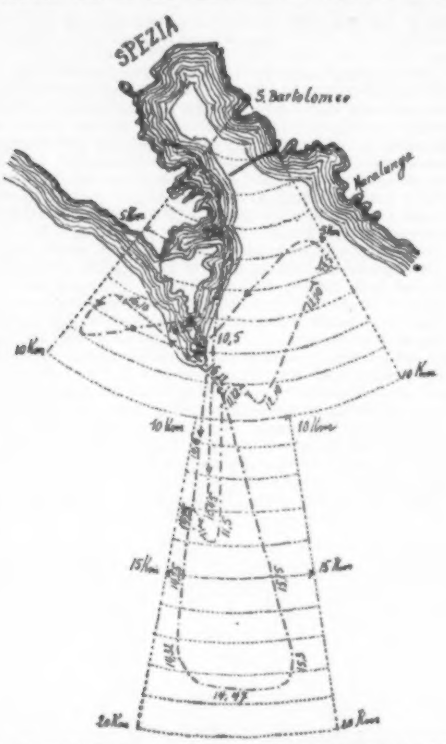


FIG. 16.—COURSE OF THE "SAN MARTINO" IN THE SPEZIA EXPERIMENTS.

history of wireless telegraphy. These steps are fixed by the following experiments:

1. The experiments at Spezia which attracted attention by reason of their official character and the cooperation of the Italian navy.

2. The experiments conducted between Dover and Boulogne, which are very important because they demonstrated the possibility of placing in communication two countries separated by water, and which first made known the great improvement in the system.

3. The experiments between Biot and Calvi which placed Corsica and France in communication, and which were the first attempts at long distance communication (175 kilometers or 108.675 miles).

4. The experiments conducted between Poole and St. Catharine, which showed the possibility of substituting suitable cylinders for long antennæ.

5. The transatlantic experiments conducted between England and America.

The Spezia experiments were conducted in July, 1897. The most important was that made on the 18th, when messages were sent from a fixed station at San Bartoloméo, with a 34-meter antenna, to the ship "San Martino," fitted with a 28-meter antenna. The course of the "San Martino" is indicated in Fig. 16. Signals ceased to be received at 18 kilometers. The transmission was better when the ship drew away than when she approached San Bartoloméo, which fact is explained by the position of the antennæ (Fig. 17). In the first case, the antennæ were approximately parallel, so that the maximum electric induction was obtained. It was also observed that obstacles often interrupted communication.

The apparatus employed by Marconi at Spezia were

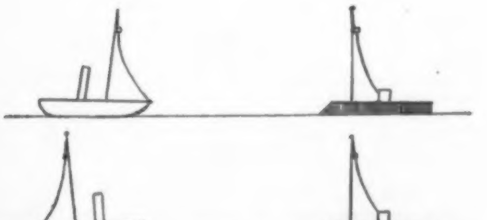


FIG. 17.—POSITIONS OF THE ANTENNÆ IN THE SPEZIA EXPERIMENTS.

the same as those pictured in Figs. 14 and 15. They are also to be seen in Fig. 18, which represents the transmitter, and Fig. 19, which represents the receiver.

During the course of the experiments with which we are at present concerned, Marconi's assistants made observations, which should here be mentioned.

Lieutenant Della Riccia proposed the abandonment of the Righi oscillator and the retention of only the two outer balls (Rivista di Artiglierie e Genio, September, 1897). Della Riccia suggested to Marconi that the advantage of the Righi oscillator of producing waves of very high frequency disappeared when a long vertical antenna was used, acting, as it did, precisely in the contrary manner from the Righi oscillator; in other words, it lengthened the period of the waves. To this objection I may add another, namely, the production of three sparks instead of one can only augment the loss in the form of heat and light, a loss which amounts to 50 per cent of the total energy. Della Riccia also observed that in order to subject the receiver to the direct action of the transmitter, it would be advantageous to inclose the former in a metallic casing. As we shall see further on Marconi in his patents and in his later experiments adopted Della Riccia's suggestions.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

In March, 1899, about two years later, Marconi carried out a series of experiments for the purpose of sending messages across the English Channel (Fig. 20). Stations were located (1) between South Foreland and Wimereux, a distance of 46 kilometers (28.366 miles), with antennæ 37 meters (121.36 feet) tall, the two stations being in sight of each other; (2) between the war vessel "Ibis" (Fig. 20) and the lightship "Goodwin," a distance of 20 kilometers (12.4 miles), with antennæ respectively 22 meters (72.16 feet) and 24 meters (78.72 feet) in height; (3) between the "Ibis" and South Foreland, a distance of 30 kilometers (18.6 miles), with antennæ of 22 meters (72.16 feet) and 45 meters (147.6 feet); (4) between Vienne and South Foreland, a distance of 52 kilometers (32.29 miles), with antennæ 31 meters (101.68 feet) and 37 meters (121.36 feet) tall.

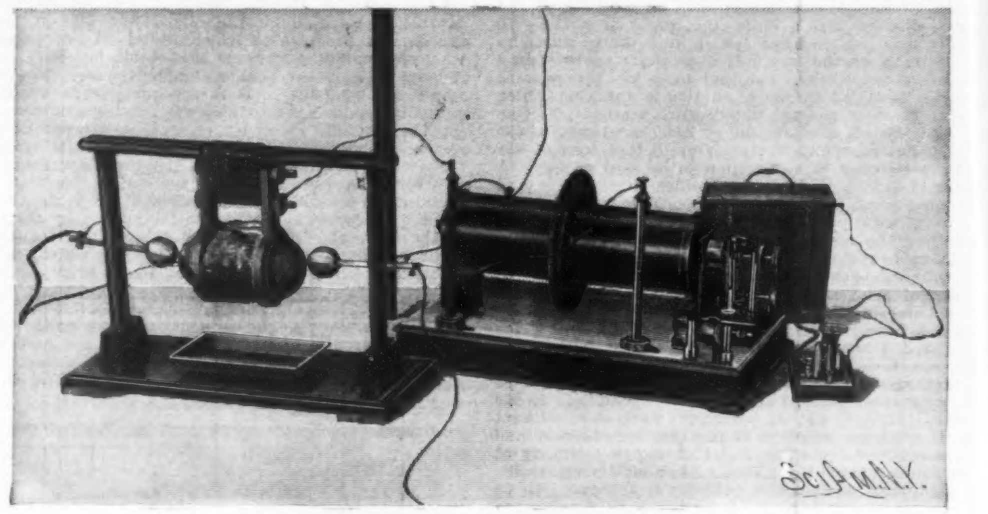


FIG. 18.—MARCONI'S TRANSMITTER.

The transmitter was constructed in accordance with the plan outlined by Della Riccia in 1897, and comprised a two-ball oscillator, connected with the earth and with an antenna (Fig. 22). To avoid the perturbations caused by atmospheric electricity, and above all, to realize syntonization, Marconi made use of his receiver (Fig. 23), in which the antenna is connected with the earth across the primary winding of an induction coil, the secondary winding being included in the circuit of a condenser and coherer connected up in the ordinary way. This arrangement enabled Marconi to attain two ends: (1) a more rapid communication; (2) communication at greater distances. Since this may seem somewhat strange at first blush, a word or two of explanation may not be out of place.

We have already remarked that the coherer is a condenser which operates when the charge q is sufficient. In every condenser the charge q is equal to CV^2t, in which C is the capacity of the coherer, V the difference of potential at the terminals, and t the time

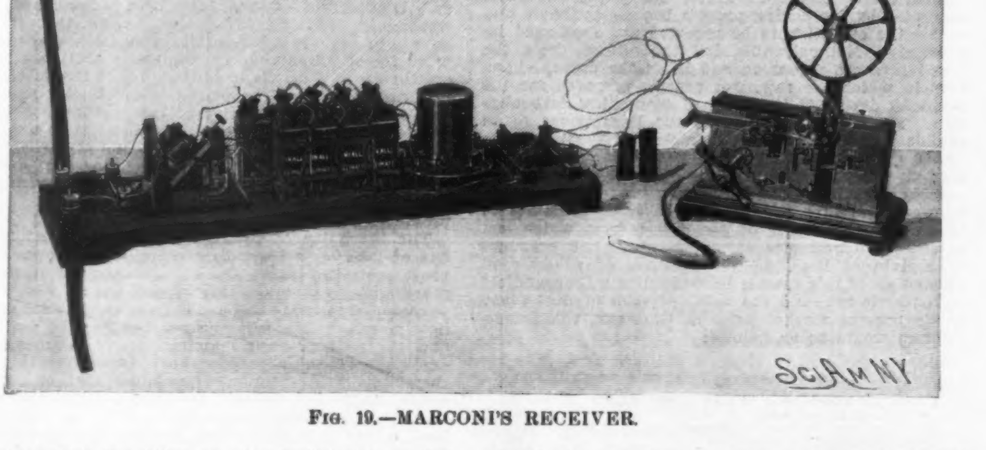


FIG. 19.—MARCONI'S RECEIVER.

during which the difference of potential V is applied. The transformer effects the transformation of the wave from a low tension to a high tension. Keeping the term q constant, the term t can be diminished in value. As a result, the speed of transmission is increased. Furthermore by the same increase in value of the term V a charge q is obtained without increasing the value of the term t, which means that the distance of transmission can be increased, while the necessary speed for intercourse is still preserved.

The receiver is inclosed in a metallic casing. In Fig. 24 it is shown with its many details. The illustration indicates the many protective devices of which Marconi makes use to prevent the action of the local transmitter on the coherer. In the installations which have been mentioned, a single antenna (Fig. 25) is employed for the transmission and reception of messages, unison being attained in a rather primitive way, by means of two metallic nets connected with the earth, the one net extending toward and the other from the antenna. The antenna was extended over the water probably to prevent the pencil of rays emitted from reaching the receiving antenna at a too-elevated point (Fig. 26).

An accident prevented Marconi from extensively carrying out his experiments in transmitting messages secretly by syntonization. But the commission which reported upon his work considered it possible that beyond a radius of 2½ kilometers (11.5 miles), syntonization could be realized.

Since I shall presently demonstrate that syntonization can never absolutely solve the problem of attaining either secret or multiplex communication, and since there is considerable skepticism as to the effects of syntonization, a word or two on the subject may not be here out of place.

A glance at Fig. 27, which illustrates Marconi's receiver, the secondary winding being represented by a straight line for the sake of clearness, will serve to aid the explanation. In the primary circuit, a is the antenna, b the condenser, h and d are respectively the loops of two waves, the first equal in length to 2 bc, the second to 4 bc. Starting with the conception that at the condenser there is a node, it is evident that if the coherer c be inserted at a point of the secondary winding of the induction coil corresponding with the loop d, its location will be at a point which corresponds with the node of a wave of which h is the loop. It is known that Marconi employs a secondary winding, having a length equal to a quarter of the wave length. Let us suppose that signals are sent with waves some of which are equal in length to 2 bc, and some to 4 bc. The coherer c will respond to the first waves, but not to the second. It is upon this phenomenon that the possibility of transmitting messages in secret is based. But the maintenance of secrecy is by no means guaranteed. Many circumstances may intervene to prevent it.

If we transmit two waves, each having one of the lengths specified, and if a double receiver be employed, the secondary windings of the coils of which have respectively wave lengths of $4\frac{bc}{4}$ and $2\frac{bc}{4}$, it can be demonstrated by analogous reasoning that each receiver can be operated independently of the other and simultaneously with it. In this manner multicommunication is obtained.

In the spring of 1900 during the experiments conducted between Poole and St. Catharine, a distance of 31 miles, Marconi substituted for the long vertical

antenna the concentric cylinders shown in Fig. 28. When wires of great length were employed electrodynamic induction predominated; when cylinders were used electrostatic induction predominated. The system of two concentric cylinders, one of which, the inner, is connected with the earth, offers great capacity.

The waves in traveling from Poole to St. Catharine

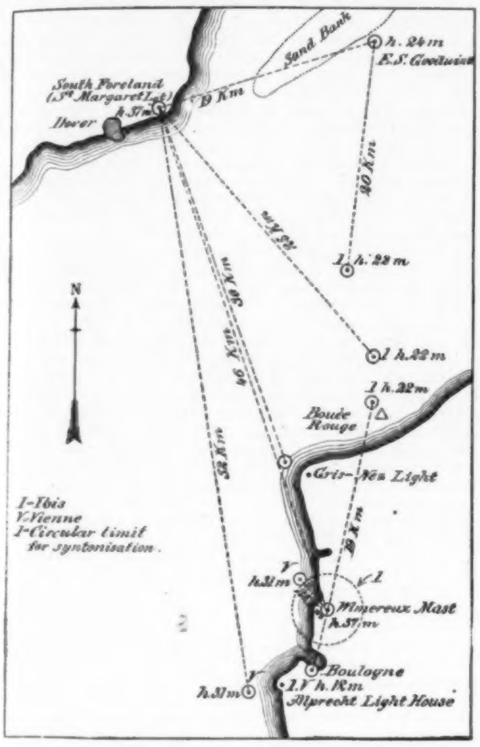


FIG. 20.—MARCONI'S CHANNEL EXPERIMENTS.

passed through the water (Fig. 29). The lines of electric force passed through the water as light passes through a translucent body. Assuming the lines of electric force to be perpendicular to the surface of the cylinders (Fig. 29), then, in order to obtain the best effect (that is to say, without reflections from the bottom of the sea), the two cylinders should be included between planes normal to their bases. If the system of cylinders has not so far been widely applied, the reason is to be found in the fact that obstacles have absorbed a very large amount of the energy of the lines of electric force, and that some means of directing the waves (orientation) is necessary to obtain the best effects. The cylinders employed in the experiments mentioned were 1.5 meters (4.9 feet) in diameter and 7 meters (22.96 feet) in height. These experiments are of considerable historical importance by reason of the attempts made at multi-communication by Marconi and his associate, Prof. Fleming.

In 1899 Prof. Braun and myself first suggested the advantages which would be presented by the use of multiple antennæ, later used by Slaby. Prof. Braun and myself (in our Belgian patent of June 24, 1899, and in our English patent 1555 of January 24, 1900) explained the advantages to be derived by the use of receiving antennæ of large surface.

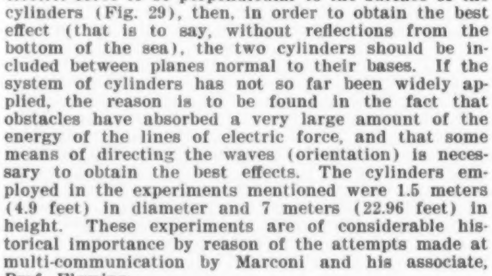
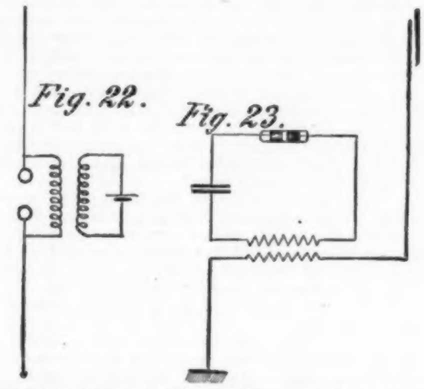


FIG. 21.—MARCONI ON THE "PHILADELPHIA."

The "jigger" employed by Marconi in transmitting messages across the English Channel did not give all the results that might have been obtained. While in the arrangement shown in Fig. 6, the coherer was inserted between two loops of the tension of contrary signs, in the "jigger" of 1899 it was inserted between a node (condenser) and a loop.

In the apparatus employed in transmitting messages between Corsica and France the arrangement shown in Fig. 6 was combined with a transformer. This transformer had been suggested by Lodge, not for the purpose for which it was ultimately used, but simply for the purpose of increasing the tension of the wave.

The problem of preventing the absorption and the loss of energy which a wave is subjected to as it travels through space, which absorption and loss become greater as the distance increases, presented no little difficulty. In the first place, it was necessary to find some way of increasing the energy without making use of a return circuit, or, in other words, it was necessary to employ, for example, an open circuit. The energy of discharge, CV^2, depends upon the difference of potential between the terminals of the secondary winding and of the capacity of the system. If the term V can be increased only to a very limited degree in practice, it is clearly necessary to change the value of the term C as much as possible. In my experiments in 1900, described in the London Electrician, for November 9, 1900, a transmitter was used somewhat similar in design to that successfully employed by De Forest. An oscillator was used connected with an antenna and with the earth, the condenser being in turn connected with the oscillator. This arrangement was far from being ideal. The oscillating current, instead of passing through the antenna, suffered considerable loss in the closed circuit (condenser). At any rate the antenna had only



TRANSMITTER AND RECEIVER USED IN THE CHANNEL EXPERIMENTS.

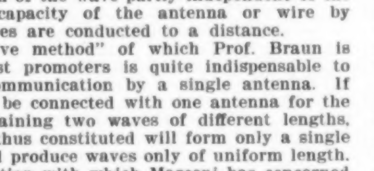
the feeble capacity which could be given to it in practice, and was not in a closed circuit.

A simple solution would evidently be to dispose the antenna near the closed circuit through which the oscillating discharge flows. This solution is covered in the seventh claim of my Belgian patent of June 24, 1899, and in the third claim of my English patent 1555 of January 24, 1900. It should be remarked, however, that I had in view an entirely different object, namely, attaining multi-communication by rendering the length of the wave partly independent of the self-induction capacity of the antenna or wire by which the waves are conducted to a distance.

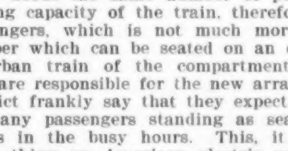
The "inductive method" of which Prof. Braun is one of the first promoters is quite indispensable to obtain multi-communication by a single antenna. If two oscillators be connected with one antenna for the purpose of obtaining two waves of different lengths, the apparatus thus constituted will form only a single system and will produce waves only of uniform length.

Another question with which Marconi has concerned himself is the speed of transmission, which speed depends, among other things, on the constant of time to establish the current in the primary winding of the induction coil. This constant of time in turn depends upon the intensity of the current, the capacity, and the self-induction of the circuit. One of the means adopted consists in dividing the power and in employing several coils with the primary windings connected in series, and in utilizing a current of high tension but of feeble strength. We shall now examine the very skillful manner in which Marconi solved the different problems presented.

(To be continued.)



The antenna and its position.



The receiver and its details.

MARCONI'S ANTENNA AND RECEIVER.

ELECTRIC TRAINS FOR LONDON RAILWAY.

THE first two trains built in connection with the "electrification" of the Metropolitan District Railway have been recently delivered to the company, and are now at South Harrow, where they are being fitted with their electrical equipment before being worked in a series of trial trips over the new section of railway between that place and Ealing. This line, though it has been completed for about two years, has not been opened to the public, and it is now being used as a sort of training ground in connection with the "electrification," a small power station having been built to supply the electric current, as the main station at Chelsea is still far from complete. The new trains are interesting as constituting a great departure from all former British practice in railway carriage design, the only cars at all resembling them being those in use on the Central London Railway. The District cars are painted a bright yellow and they are thoroughly American, both in appearance and in arrangement, though they were built at Loughborough, in England. They are much more like tramcars than railway carriages, as all the seats are placed longitudinally along the sides, with a broad corridor running down the middle. The doors are, of course, at the ends of the cars, with platform gates to be manipulated by a conductor standing between the cars as on the Central London Railway. But the

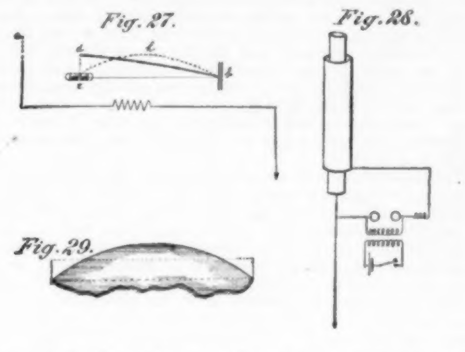


FIG. 27.—MARCONI'S "JIGGER." FIG. 28.—CONCENTRIC CYLINDERS. FIG. 29.—COURSE OF WAVES THROUGH WATER.

District cars also have side doors in the middle, which, however, do not open outward as in an ordinary railway carriage, but slide, handles being provided to enable them to be worked either from within the car or from the station platforms. It is possible that these side doors may not be used in the ordinary way, but treated as emergency exits; or they may be used only at stations where a large number of people desire to alight at one time. There are seven cars to each train, and each car is 50 feet long and holds about the same number of people. The total seating capacity of the train, therefore, is about 350 passengers, which is not much more than half the number which can be seated on an ordinary English suburban train of the compartmental type. Those who are responsible for the new arrangements on the District frankly say that they expect to carry almost as many passengers standing as seated in the new trains in the busy hours. This, it appears, is the usual thing on American electric railways, and the wide passage between the seats with straps hanging from the roof is designed for this end. Whether the London traveler will take kindly to this arrangement remains to be seen. Its advocates contend that with real "rapid transit"—i. e., very frequent trains traveling at high speed and spending the minimum of time at the stations—the objection to standing in the cars largely disappears. This has to some extent been the experience on the Central London Railway.

There are several other new features in the internal fittings of the new District cars. One is the absence of all cloth or stuffing in the upholstery, the seats being all covered with the material known as "rattan." This is done in the interests of cleanliness; in fact there is nothing inside these cars which cannot be washed over every day. All the material employed is as far as possible fireproof, the wood having been treated by the patent "non-inflammable" process while the ceilings are lined with asbestos. But for this precaution one might apprehend danger of fire from the electric "heaters," sixteen of which are placed under the seats of each car. This heating apparatus is an American patent and finds much favor in that country, but it is quite new in an English suburban train.

Practically all the electrical equipment for driving

the trains is carried under the floors of the three motor cars, which are placed one at each end of the train and one in the middle. A small space above the floor of each of these cars is required for the motorman's cabin; but with this exception the entire length of these cars, as of the "trailers," is available for the service of the public. On the two end motor cars of the District trains luggage lockers have been provided. There is, of course, no locomotive, as the trains are driven by what is known as the "multiple-unit" system. Apart from the saving in weight and length of train resulting from this system of traction, it has the great advantage of easy adaptation to the needs of the traffic. These seven-car trains, for instance, can at any time be split up into two trains, one of three and the other of four cars, or into three trains of correspondingly shorter lengths or a single motor car can run if the traffic be exceptionally light. One of the principal objects of the trial trips about to be run between Harrow and Ealing is to decide which is the best system of "master control" for these "multiple units." Accordingly one of the trains has been fitted with the Thomson-Houston system and the other with the Westinghouse. The former is purely electrical, whereas the latter is electro-pneumatic.

So far as the fittings of the cars of these new trains are concerned, no distinctions of "class" are observable. Of course, if in this matter also American practice be followed, there will be one class only on the "electrified" District Railway, but no final decision has been come to on this point. It is possible that, as a concession to British custom, some of the cars will be labeled "reserved," and for these, of course, an extra fare would be charged. Apart from this, it is understood to be the intention of the authorities to introduce a uniform fare of about 2½d. for any distance.—Correspondent of London Times.

INDUSTRIAL TRUSTS.

By Prof. W. SMART, LL.D.

THE subject is a large one to cover in an hour, and I shall not waste time, either by introduction or by dwelling on matters of common knowledge.

The two sides of the phenomena we have agreed to call Trusts—the good and the bad—are summed up in two words, Economy and Monopoly.

First, of Economy. Ever since Adam Smith we have been familiar with the economies of large production. But a Trust is more than a large producing unit. It is an amalgamation of organizations which have separately exhausted the economies of large production possible to them, and which find a new saving in organizing these separate organizations. Thus the possible economies are very great. They are, briefly, four.

1. The usual economies of production on the very largest scale—economy in manufacture, in buying, in selling, in office work, in warehousing, in freighting, in financing; and, besides, the utilization of many by-products which would be wasted in smaller scale production.

2. The saving of the waste involved in keeping up, pushing, and advertising separate and rival businesses; every amalgamation at once reduces a crowd of employes to the position of mere middlemen—as for instance, the 300 travelers dispensed with by the Whiskey Trust.

3. The competitive bookkeeping—the check and stimulus involved in comparisons between the working of businesses which have hitherto been worked on various principles, but will, sooner or later, be worked only on the ascertained best.

4. The possibility of extreme specialization—separate mills or plants being set aside to do certain things exclusively.

Consider for a moment only one of these economies. What is the gain of advertisement—the gain to the community apart from the gain to the advertiser? There may be such a gain on the introduction of a commodity, when new utilities are to be brought to public notice. But, apart from this, it seems to be the case that what one seller gains by advertising, another loses, the community buying no more. Advertising, I mean to say, will perhaps induce me to buy Pears' soap instead of Vinolia soap, but it will scarcely induce me to buy more soap. If this is the case, we must say that enormous sums are spent by producers purely in a struggle to take away trade from each other, without adding anything to the total product of the community's industry.

Here, then, if anywhere is the defense of the Trust. It is a long step toward the maximizing of product and the minimizing of effort, which is said to be the goal of economic progress. If we could be sure that these huge economies fell into the proper hands—say a perfectly upright and perfectly capable municipality giving these economies to the people in the shape of cost prices—there would be little to be said against the idea of the Trust.

At the same time, it should not be overlooked, or dismissed as not worth consideration, that such economies have a debit side. Works cannot be shut down, workers turned off, employers crushed or bought out, acquired skill made useless, without much individual suffering, and there will be this suffering into whatever hands the economies fall. And there is, no doubt, a certain loss involved in the elimination of the independent producer. There are some things in independence which are worth preserving for themselves; the struggle of the small man upward makes for character, resource, and initiative. But, as a fact, this argument has practically got its death blow from the working classes themselves; the greatest foe of the small producer is the co-operative society.

So far, then, as this side goes, trusts are phenomena of economic progress. They are the elimination of the unnecessary person, the unnecessary process, and the unnecessary thing in the production and distribution of goods.

Second, of Monopoly. By natural evolution such great economic organizations tend to become, and often actually are, private monopolies. Now monopolies have three very dangerous powers; over price, over improvements, over labor.

I. The Power Over Price.—In virtue of the great economies just mentioned, Trusts should result in low prices. But when the economies fall into single and powerful hands, this by no means follows. It may be said generally that monopolists will charge as high prices as they can economically demand.

There are, of course, very serious limits to this power. There is the fact (1) that demand generally falls off as prices rise; (2) that no monopoly is absolute; the higher the price is driven, the more tempting the inducement to break in on it; (3) that what the monopolist aims at is high profits, and that equally high profits may be made—and more safely made—from a large output at low prices as from a restricted output at high prices; and (4) there is the presence of substitutes for the monopolized goods—as science grows, the field of supply for any human want widens.

To this may be added a fifth limit—the desirability of conciliating public opinion. The morning after the announcement of the Harvesters' Trust, Mr. Morgan declared that its first step would be a 10 per cent reduction in the price of agricultural implements, adding significantly, "the companies could stand a further reduction in the export trade."

As a result of these limits, we do not, as a rule, find that, when a product becomes monopolized, its price is raised unless where heavy cutting has attended the formation of the monopoly—and one is apt to forget that, with all these economies, the price might have been expected very greatly to fall.

On the other hand, there is a special feature in modern monopolies which seems to make for high prices. It is that a new element of cost is added by the capitalization. In the formation of a monopolist amalgamation, plants are not valued so much by their producing power as by the necessity of taking in as many businesses as possible. Stock accordingly is issued against concerns bought at a ridiculously high valuation; the stock gets into the hands of the public, and dividends are demanded on the whole of the issued capital. If the monopoly is effective, the demand is met, and the dividends got by raising prices. It is the same where large amounts of stock are given to promoters and underwriters. Moreover, by watering stock in this fashion the public is quite misled, and easily swallows the contention that prices cannot be unduly high, seeing that so much of the stock is paying no dividend.

II. The Power Over Improvements.—The monopolist whose position is secured will not make the same experiments or run the same risks as competitive industry would. Monopoly takes away the chief stimulus to improvement of organization and process, the fear of being undersold by the new comer, the person who, presumably, has the latest appliances for reducing cost. And what the monopolist will not do himself, he will prevent others doing. Where he has a wide and varied market, he can crush the new comer, not by the power of working more economically, but by concentrating his attack on a few points.

III. The Power Over Labor.—This must necessarily be very great. Where a dozen employers are rolled into one, monopoly means restriction of the competition for labor which would otherwise exist among employers, and throws the advantage in the wage bargaining heavily against the worker. It need not be assumed that the advantage will be exerted to the utmost. Enlightened monopolists, like other employers, know that highly paid labor is cheap labor, and, with all the economies of combination there should be ample room for rising wages. And neither Trusts nor Combines seem markedly hostile to trades unions. But the power is there.

These are the three dangerous powers which monopoly possesses. It by no means follows that the persons in whose hands the monopoly is will use these powers badly. Monopoly is a private interest, but private interest need not be incompatible with a large measure of public interest; may, indeed, be the same as the public interest. And, further, although the monopolist may make his fortune by attending to his private interest, he may spend it entirely in the public interest—or what he conceives to be so. But, human nature being what it is, it will be generally agreed that such powers are too great to leave unreservedly in private hands.

And for this reason there seems to me one conclusion to be drawn, although I state it with some hesitation. It is that, if we are convinced that such huge organizations, with their inevitable tendency to monopoly, are the forms which industry is going to assume in the future, it might be advisable, where we can, to secure that industries which, by their nature, must be monopolies in any case, should be taken over by municipalities before they grow too large and too dear to be taken over. If the danger to progress, and danger to labor can be thus avoided, and if the profits, which would otherwise fall to monopolists, can be used to reduce the prices of goods, it seems legitimate argument for municipalization.

The problem, then, which all countries have to face is how to preserve the economies of these great organizations, while preventing the evils which arise from monopoly.

To pass now from general theory, and consider the present situation in the light of it. On both sides of the Atlantic, of late years, we have the emergence of what seems a similar phenomenon, the amalgamation of a great many businesses into one. In America, curiously enough, these bodies are called by the fine Saxon term, Trust; with us, they are known by the eminently American term, Combine. Are they really the same phenomenon? I think I shall be able to show that, while presenting many features of resemblance, they are different in origin, different in many respects in constitution, and different in issue.

The features of resemblance are these:

1. They are both very large, as regards the capital and as regards the businesses combining. The Democratic Congressional Committee has issued a list of 287 trusts, with a total capital of seven milliards of dollars (£1,400,000,000); and this list does not include combinations based on price and rate-fixing agreements, profit-sharing pools, buying and selling arrangements, nor does it include what are pleasantly known as "friendly agreements among gentlemen," such as the so-called Beef Trust—the "Big Four." The Harvesters' Company has a capitalization of £24,000,000, the Amalgamated Copper Company of £31,000,000, the Imperial Tobacco Company of £52,000,000, and the United States Steel Corporation of no less than £280,000,000. We, on this side, have the United Alkali Company and the Calico Printers, each with over eight millions of capital, embracing respectively 51 and 47 firms; the Bleachers Association, the Fine Spinners, the Portland Cement Manufacturers, each with over six millions of capital, and embracing respectively 53, 47, and 30 firms. We have the Wallpaper Manufacturers with over four millions of capital, turning out 98 per cent of the total product of wallpapers, and so on. Besides these, we have the international thread combines, in which three separate but allied organizations produce, I think I may say, practically the whole of the cotton thread used in the British Empire and in the United States.

2. The movement in both countries is of very recent date. I have beside me a list of 82 trusts, with a total capital of $4,328,000,000 (£865,600,000), formed within the last three and a half years. The most of our combines came out between 1898 and 1899.

3. The form of organization is very much the same in both countries. The name "Trust" is, of course, a misnomer; the kind of organization where a number of businesses transferred themselves to a body of trustees, getting in exchange "trust certificates," is illegal since 1890, and the prevailing form of trust now is the same as that of our combines—one large single company which has acquired outright all the different plants, patents, and goodwills.

The differences, however, are very great.

I. As Regards Origin.—The difference cannot be put better than in Mr. Crewdson's words: "The trust was designed primarily as a weapon of war, aggression and attack. The amalgamation is primarily a measure of self-defense and peace." The history of most of our amalgamations may, I think, be summarized thus: First, a long period during which the firms work alongside each other in a good-natured old-fashioned way—competing, indeed, but not "poaching," as it would have been called once upon a day. Then the intrusion of new comers, who are not content to make a trade for themselves by taking up new demand, but wish to carve a kingdom out of other people's territories, and take the short way of cutting prices. If the old firms do not follow, they lose trade; if they follow, they lose money. Suppose they follow, and the new comers go lower still, this will cure itself no doubt in time, but it may be a very long time. For it is more than likely that the new comers have put up their mills more cheaply and have got together a more economic organization, and it is by no means certain which will go to the wall. In any case, it will be a long time before this is decided; once the new factories are built and started, there is no discharge in this war. To stop, means losing everything—or nearly everything—but scrap value; and it means even worse to the old firms, whose owners are, in all probability, fitted to do nothing else, and live on their capital till the capital has disappeared. The truth of this is written in hundreds of old mills one comes across in the country, working alongside new mills, with which they cannot possibly compete on equal terms. It is only in text-books that losing firms close down and relieve the competition. So one of the firms, perhaps, getting tired of the long prospect of non-paying years, proposes an agreement. By this each gives up the hope of seeing all but itself disappear, but each gains security and profits. The first step is a common price-list and common terms; and this first step is taken by many industries which never go further along the way that ends in a combine. It may or may not be accompanied by differential limitation or proportioning of output over the firms.

But this common price-list of itself points to a further step. It brings to light many forms of waste involved in keeping up separate organizations, and suggests how these might be got rid of. In other directions, the common price-list causes new expenditure; for, in this case, the only thing that can sell goods—cutting being ended—is advertising. Any hundred a year "commercial" can sell goods if he is allowed to offer better prices or terms, but it takes a highly-paid man to sell when he can give no such monetary inducement.

While economy thus suggests a further step, the known impossibility of working a common price-list agreement without endless quarrels emphasizes it. I do not say that where three people come to an agreement, one at least will be thinking all the time how to get round it or break it without being found out. But I do say that, of the three, two will suspect at least one, and will not always waste time in proving whether he is guilty or not, but will make reprisals. And I will say further, that the most honest gentleman cannot, do what he will, control the actions of dozens or scores of agents and travelers. And so the history of all common price-list agreements—I should say without exception—is that they are constantly being broken, patched up, and broken again.

From the common price list then, to the central selling agency—an agency which sends out travelers and employs agents to sell three or four brands, does all the office work under one roof, and by one organization, and where underselling is made almost impossible—is an obvious step dictated by economy; and, from the selling agency to the closer union known as combine, is really a much shorter step.

In the above I am sketching from life—from the annals of a trade I know; but I have no doubt that very much the same history led up to all our combines. The negative cause was cut-throat competition; the positive, the possibility of large economies.

According to Mr. Havemeyer, the origin of the American trust is the same. The high tariff, he says, making the protected industry very profitable, tempts much capital into it. Plants are carelessly put down in unfavorable locations, and unqualified men become employers. The pressure of home competition becomes very severe, and the only safety is combination. This is what he meant by the often quoted dictum—

usually misunderstood—that "the mother of all trusts is the customs tariff law." It is a curious commentary on the accepted theory that protection means the restriction but not the annihilation of competition; that it aims only at putting the home producer on an equality with the foreign producer who sends in goods made at a lower cost. On Mr. Havemeyer's reading, protection appears as leading straight to the disappearance of foreign competition; to congestion of capital in the home market; and to internal competition so severe that the home producers themselves require a second protection—protection from each other!

But whatever we may think of his reading, we need have no difficulty in accepting the statement that excessive competition, and the evident economies of large production, are the economic bases of the trust. But there is this difference; that the trust has been very greatly the work of the promoter and financier. Manufacturers have been tempted into trusts by extravagant prices offered them by outsiders. This is reflected in their notorious capitalization. The principle of at least many of the capitalizations, seems to be that every £100 of real value of assets is capitalized at £100 of bonds or preferred stock, plus another £100 of ordinary stock. If the bonds or preferred stock are kept at par, and pay their dividend, the vendors are fully paid; and although the ordinary stock may never pay a penny, there is always the chance of selling it for something. As to promoters' profits on the transaction, they are usually estimated at 20 to 40 per cent of the capital stock issued. Here, of course, is stock manufactured, like the famous razors, to sell. Those who get it have no interest in the welfare of the business—only in the success of the promotion. There is one case often quoted—that of the Standard Distilling and Distributing Company —where each plant valued at $100,000 had to earn a dividend on $600,000.

It may be safely said that our English combines stand comparison with this. The worst that can be said of any of them is that they embrace many rotten members, for which a large price was paid; but this price was not paid to water the stock for selling purposes. Nor has the capitalization been increased to any scandalous extent by payments to promoters. The concerns combined were not, indeed, of such a doubtful character that they needed strong promoting and financing. At the time when so many were formed, it was considered a favor to get an allotment; and, as Mr. Crewdson has said, there was no need for underwriting. The capital not taken up by the public was taken up by the vendors; and, as a fact, there was much grumbling at the Stock Exchange limit, which prevents vendors taking more than one-third the purchase price in stock.

In a word, our combines are a last stage on the evolution of the system which Adam Smith called "Natural Liberty." I hold that they are as "natural" as the system itself. As the world grows wealthier, competition grows keener—for the reason that production always tends to out-run consumption—and cut-throat competition suggests its own remedy of combination. And the combination saves us from something worse, the monopoly of the survivor. Trusts, on the other hand, are the somewhat artificial evolution of the essentially artificial system called protection.

II. As Regards Issue.—Both forms of organization, indeed, aim at being monopolies. The difference is that while, thanks to protection, the trusts, secured against competition from outside, may attain effective monopoly within their own country, and enjoy the high prices of monopoly, our combines, living under the fierce struggle of competition with all the world, can survive only at the cost of eternal vigilance, efficiency, and low cost. Neither the actual nor the possible competitor is likely to perish out of the land in a free trade country. And it may be noted that there is this further difference in issue, that our combines have not, as a rule, been strikingly successful. Hence we see, meantime at least, a distinct check to the formation of further combines. Will anyone say that, suppose a new combine were floated to-morrow, there would be a rush to obtain shares, such as there undoubtedly was three years ago? But in America there has been no such check.

III. As Regards Constitution.—Thanks to our strict Companies' Acts, our combines are carried on under the public eye. The balance sheets and annual meetings get into the public prints. The rights of shareholders are defined and exercised. The powers of directors are strictly limited. But in America one has the extraordinary spectacle of a competition between States which shall give the most elastic articles of incorporation and the cheapest, not only as regards charter fees, but as regards taxation. New Jersey, for instance, gives a charter for any lawful business or purpose whatever, demands no limitation of the capital stock, does not exact annual meetings, and allows directors to apply surplus earnings to the purchase of property—including their own capital stock —"from time to time, to such extent, and upon such terms as the board of directors shall determine." But West Virginia is overbidding her. Here the fee is only $56, and the annual tax $50. No director need be resident in the State; annual and other meetings may be held outside the State.

As a consequence, it is said, no one buying the stock of a trust company knows what he is buying—either what has been paid to vendors, promoters, and underwriters, or what assets these payments represent; the powers given to directors, officers, and shareholders respectively are not defined in the certificate of incorporation; detailed and audited accounts are not published yearly; no information is obtainable as to the methods and conduct of the business.

Thinking over these three differences of origin, of constitution, and of issue, it has seemed to me that there is a peculiar difference between American conditions and ours which underlies and partly explains the other three. It is the appearance in America of a new class, that of the business millionaire—a phenomenon so new that we have scarcely appreciated or studied it sufficiently.

It has been said that some 87 per cent of the millionaires in America have built up their fortunes from the very bottom. That is to say: they are not men of leisure and culture, administrators and statesmen, not even landowners, but restless, energetic, tireless men, whose thoughts are concentrated up till old age on one thing, business.

Now if these men are magnates in many trusts, and the trusts work into each others' hands; if they control, to a great extent, the railways, while the railways themselves own coal and mineral and oil lands, and can exert the immense influence of differential railway rating; if such men exert, as they necessarily do, great political influence both on legislation and administration; and if industry generally is carried on under the highly artificial system of protection, I think little more need be said to prove that the trust becomes something essentially different from the combine both in its conduct and its issues.

If the differences then between trusts and combines are so great, it is not illogical to conclude that the treatment must be different; or that, at any rate, if "something must be done" in the one case, it by no means follows that anything should be done in the other.

Public opinion in America seems thoroughly roused against the trusts. The President himself is reported to have said that "these enormous monopolies whose actions result in evil, must be broken," although, it must be confessed, he does not seem very clear, either as to the nature of their offending, or as to the remedies. This feeling has taken the direction of anti-trust legislation. Twenty-seven States and Territories make trusts punishable by fine and imprisonment, and there is, besides, the Federal Anti-Trust Law of 1891, to the passing of which, it may be noted, Tammany gave its support. But, hitherto, all such legislation has been utterly futile. If you study the wording of these acts, with their emphasis and dependence on such loose phrases as "restraint of trade," and "attempt to monopolize," you will understand why they have failed, and agree, I think, that they deserved to fail.

Conscious of this, politicians and economists are directing their thoughts, not to legislation against trusts, but to legislation against certain acts usually associated with trusts, such as cutting prices below cost with intention to crush, contracts of exclusive dealing, and the like.

I must say that I cannot understand legislation on such lines. No business man would say that such acts have come into existence with trusts; they are the commonest phenomena of all keenly contested business. Instead of being anti-trust legislation, this would be legislation against ordinary incidents of competition. Where convictions would turn on such questions as whether a trust was selling above, at, or under cost—particularly when it was the cost of one single article out of a whole price list; whether there was "intention" to crush as distinct from legitimate retaliation or business policy to meet a new demand, etc., legislation is not so much hopeless as ridiculous.

There is another proposal much canvassed; it seems likely to be adopted as a political "plank" by the Democrats, and has met with some support from economists. It is to withdraw the protection of the tariff from industries which have passed under the control of trusts, and let them meet foreign competition. The objection is obvious enough; that, if such drastic measures were taken against trusts, the first to go under would be, not the trusts, but the competitors and rivals that still survive. Even economists who have no love of protection shrink from its sudden and violent withdrawal. Meanwhile, the President seems to have given a new lease of occupation to the trusts in announcing that he means no interference with the tariff.

There are certain measures, however, which cannot be called anti-trust legislation, and yet would go far to prevent the chief evils of trusts.

One is strict legislation, uniform over the States, as regards the promotion, constitution, and subsequent conduct of public companies. Without claiming finality for our legislation, we may point to our Companies Acts, and particularly the Amendment Act of 1900, as an example which might very well be followed by the United States.

The other is legislation which would be effectual in stopping preferential railway rating—an abuse to which many attribute the success of the trusts. It will be remembered that our Railway and Canal Traffic Act of 1854 forbids any company to "make or give any undue or unreasonable preference or advantage to or in favor of any particular person or company, or any particular description of traffic in any respect whatsoever." Under this law, favoring discrimination is practically unknown. In the absence of legal prohibition, it is quite clear that competing railways will cut freight charges to secure the custom of a monopoly, and, where members of the monopoly control the railways, they are pretty certain to make use of one group of shareholders to further the interests of another. The evil is intensified where the railways are themselves owners of monopolies. There they make their freights conform to the policy of the moment as regards the goods carried. If, e. g., they are cutting the price of coal, they carry their own coal for nothing, and raise freight against competing coal. The discrimination in oil freights is, of course, a matter of history.

These abuses have not been allowed to go on without a vigorous attempt to check them; and it is a fact that, since the passing of the Inter-State Commerce Law in 1887, discrimination in freights is illegal. All the same the law is everywhere said to be inoperative. It "cannot be enforced," said the Inter-State Report, January, 1899. "Under the present law, discrimination is inevitable," said the Inter-State Commerce Commission in 1900.

Now it seems to me that merely to state the failure of American legislation, in face of the confessed evils of trusts, is enough to suggest that legislation against our combines, where similar evils have not emerged, is quite uncalled for, and would certainly be equally futile. As I have said, amalgamations are perfectly natural, meaning, by that much abused word, "what might have been expected." Competition after all ends in selection. Excessive competition could end only in the survival of the strongest—that is, in monopoly—if it did not end in combination. Unless we are prepared to legislate against competition, I cannot see that we could legislate against combination. In a word: where legislation is hopeful and possible in America, we do not need it; where it has been futile, it is directed against evils which do not exist here.

But, indeed, our anxiety about combines is surely a little uncalled for. The further division of labor is inevitable. This means further specialization. Now specialization is taking two directions. One is the combine, making certain staple goods in large quantities. Here, indeed, the small producer drops out. But the cheap standard goods made in this way form a new cheap raw material for other industries, which specialize on these as foundation. For instance, I have a friend whose business is the making of delicate electrical apparatus. When he wants standard machine tools he gets them, for the most part, from America. But when he wants special tools made to specification, he goes to France or Germany, who are able to supply them cheaply, because they, in turn, get the component parts from America. In short, on this large standard production of the combine or trust are being built up all sorts of special industries which are for ever free from being swamped by the combine.

Again, those who think of the combine as crushing out independent producers forget, I think, that it is only certain industries which can pass into combines. Wherever a man stamps his individuality upon his work, the combine is impossible. This, again, points to another division of labor which is going on under our eyes. The large routine industries, employing machinery and comparatively unskilled labor, are bound to pass into larger and larger units, because the fixed charges decrease as the output increases. But this same division of labor is throwing those who use their brains into a class by themselves. The enormous spread of journalism illustrates what I mean. The printing of the literature falls to great combinations; so does the making of the machinery. But the author works by himself. The fact just is that the spread of education is tending to throw men and women into occupations where machinery cannot touch them. Miss Collet it was, I think, who reminded us that the largest single industry in the United Kingdom is that called domestic service. As wealth and culture grow, the increasing demand is, not for more cakes and ale, but for the things which have been, ungracefully but graphically, described as "mind products"—the immaterial services which can be rendered to society only by men and women themselves. Here the principal factor of production is not machinery, but human brains. In this class of commodities, large production has no advantage, and neither trusts nor combines affect it.

But I feel bound to say that our interest in the subject does not end with academic comparisons, and with the conclusion that, as the combine is a phenomenon of economic progress, and is free from at least the greater evils of the trusts, we should and probably could do nothing to check it. It seems to me, on the contrary, that we are very much interested in the American trust, though in a way that has not yet got due recognition.

It is very often assumed as self-evident that a protective tariff favors the formation of trusts. I do not challenge the fact but I am inclined to challenge the assumption. How does it do so? Why should the exclusion of foreign competition in whole or part have anything to do with trusts? The question seems to me to admit of no answer on any lines I have laid down here. I said that the one root of combines in this country was cut-throat competition. But, in America, if there is any virtue in protection, competition is restricted. I said the other root of combines was the possible economies. But what is the special motive to economy and low cost of production where a paternal government takes the American manufacturer under its wing, and allows him to make profits rather by high prices than by low costs? And, if we are going to account for the trust by the tariff, how are we going to account for combines?

The fact is that here the word monopoly misleads us. We confuse two quite different monopolies. It is said protection leads to monopoly and trusts are monopolies. True, but the monopoly which a protective tariff tends to give is only monopoly of its home market as against outsiders. But trusts are monopolies inside this monopoly—monopolies of the few Americans against the whole body of Americans. Suppose you put a fence of a 60 per cent tariff round any industry, you enable the industry to charge up to 60 per cent higher prices; but how does this favor one protected producer more than another? That American manufacturers have a monopoly of their home industry against the Englishman is no reason that I can see why they should hasten to make themselves monopolists against each other.

Understand that I am asking whether there is any special element in protection, as distinct from free trade, that favors the formation of trusts. I think there is. It seems to me that a tariff favors and induces trusts in that it puts a special premium on large production.

Large production is, of course, cheap production, and for this reason, everybody wishes to be a large producer. What, then, prevents everyone rushing into production on the largest scale? It is, as everyone knows, the difficulty of selling an increased output without bringing down prices. If a man has a trade at ordinary paying prices, and begins to make more than he can sell at these prices, he dare not sell only the surplus at low prices. This would be a kind of revoke, calling down the wrath of his customers and spoiling his own market. So well is this understood that, in a common uniform price agreement, it is usually forbidden to sell even old stock at a reduction without taking off marks and labels and selling it as a job lot. In modern industry, we are understood to play the game. Our customers pay our list prices on the honorable understanding that they are getting the best prices and terms. They could not carry on business otherwise, for they live by selling the goods over again, and if one customer gets better prices, he cuts

the feet from under the others. And this will not hide. There is nothing more damaging to an established trade than to break one's prices; the phrase "spoiling the market" really means spoiling one's own market. Thus, in ordinary cases, although he knows that enlarged production would mean lower cost, the manufacturer extends his business only as he finds demand increasing, and this is generally a gradual process.

But protection gets over this difficulty. If, owing to a tariff, competition within a country is restricted, and prices accordingly are kept high, any surplus that cannot be sold profitably at home can be exported without spoiling the market. Thus the limit to large production is removed; overproduction at home is prevented; the fixed charges are attached to the goods sold at home, and exporting even at cost shows no loss. It will be remembered that, in 1901, the price of steel rails in the United States was approximately $29 per ton, at a time when Mr. Schwab publicly announced his readiness to deliver steel rails in England at $16.50.

Now this is nothing less than a subsidy paid by the American consumer to the foreign exporter. Just as the German manufacturer could not keep up his price for beet sugar at home to 5d., were it not that the government enables him to sell his surplus here, in competition with cane, for 2d., so the American can extend his production, and yet keep up his prices at home, because he has an unlimited market abroad where he can get rid of any surplus at a low price.

It would not pay him, of course, if he were sending the bulk of his goods abroad. But if there is any truth in Mr. Carnegie's estimate, that the home market of America takes 96 per cent of all its manufactured articles, the 4 per cent may be given away without making much difference to a dividend. If it be thought that 4 per cent is too small an outlet to relieve and prevent over-production, it should not be forgotten that the large production allows prices at home to be reduced, and so increases the sales.

Hence, I imagine, I notice a quite erroneous feeling about this action of American trusts. It is assumed that the American maker is trying to crush us out with the view of getting an international monopoly for himself—just as Mr. Morgan is often credited with this extreme form of patriotism. The American manufacturer is doing nothing of the kind. It is the American market he wants. It is the high prices under protection which he aims at getting and keeping, and the way he keeps them is by this outlet for any surplus that otherwise would spoil his own market. If one doubts this, let us ask if Mr. Schwab is repeating his offer to-day?

Compare this with our case. When our manufacturers have for the moment a surplus, they may, indeed, export it. But they have no paternal government to protect them against the competition of other nations; they are daily fighting with the whole world, and their prices accordingly are keenly competitive prices. Below that level they cannot go, and, if they export below those prices, it will be at a loss.

This, then, to my mind is the special connection between tariffs and trusts which we were seeking. Large production is the connecting link.

If I am right, it will be seen that we have a double problem as regards the great combinations. Our own combines—their power over price, over improvements, over labor—form one problem. The other problem is this new development; the American trust entering our own markets and neutral markets, under the encouragement of a bounty—and not a bounty on one article, but a bounty on all articles made by trusts and exported. This explains why American exports are not exports of one or two great articles, or of raw produce only, but a long list of small exports very much like our own. And if I am not mistaken we are more interested in the latter problem than in the former.

All the same there seems to me no reason for any pessimistic outlook. Industry, indeed, never goes back. America has set the pace in large production, and, if we are to keep our place among exporting nations, we must reconstruct many of our industries on a similarly large scale. So far as I can read the signs of the times, our manufacturers have realized this necessity. Outside of the great combines—and more quietly and successfully—they have been enlarging the unit of production in another way, namely, by the amalgamation of successive and related processes and industries, securing similar economies to those of the combines without the weakness, incidental to the formation of a monopoly, of taking in doubtful members. And, in the international race, our manufacturers are free from the heavy handicap which protection puts on export trade.

If this is the case, the "American Invasion," as it has been called, is only a blessing in disguise. I do not think, for instance, that it has been a bad thing for us, or for our manufacturers, that so many of us today are walking about in American boots. Our makers are not above taking a lesson, and improving upon it. I remember a similar invasion from France in the seventies; I remember how much good it did; and I also remember how short-lived it was. In the world of thought, we welcome every advance wherever it comes from, make it our own, and build upon it. Why should it be different in the world of industry?

I do not consider that we are losing our place among exporting nations. We must expect that countries which increase in population more rapidly than we do should increase their exports in the same ratio; if they do not do so they are falling behind, seeing that foreign trade is carried on, not by nations, but by individuals in the nation. Sir Alfred Bateman's figures, showing that, since 1875, the exports per head of the population of the four great nations have remained nearly stationary, namely, £6 for Great Britain, £3 15s. for France, £3 7s. for Germany, and £2 18s. for the United States, give us a valuable reminder of this, and show that, individual for individual, we are holding our place—with a long lead.

But even if we did not hold our own among exporting nations, it by no means follows that we are falling behind in comparative prosperity. Twenty years ago, your chairman, in one of those suggestive and far-reaching essays, for which economic science owes him so much, said that "the possible loss of income from the entire loss of our foreign trade would be a most measurable, and by no means, a fatal injury." What he meant, of course, was that our foreign trade, after all, is only a fraction of our home trade; that an increasing demand for goods made at home might easily take up all the labor and capital of the country to meet its wants. The point is very significantly illustrated by the fact that America to-day, when she cannot meet all the demand for steel at home, is more prosperous than she was last year when she was exporting it. In short, to quote Mr. Cannan's wise words: "When misleading metaphors and fallacies are dismissed, we are left with the facts that foreign trade—the trade of an area under one government with areas under other governments—is merely an incident of the division of labor, and that its magnitude and increase are no measures of the wealth and prosperity of the country, but merely of the extent to which the country finds it convenient to exchange commodities of its own growth or manufacture for commodities produced elsewhere."—Journal of Society of Arts.

LACQUER; ITS PREPARATION AND USE.*

By RANDOLPH I. GEARE.

It seems strange, and indeed unfortunate, that so dainty and fascinating an industry as the manufacture of lacquered ware has not gained a foothold in this country. In addition to its acknowledged beauty for ornamental purposes, lacquer gives a more enduring and harder surface to wood than any varnish now on the market; it takes a polish that cannot be excelled, and which, as is well known, will last for centuries; it is proof against injury from various liquids, such as boiling water, alcohol, etc.; it makes an excellent surface for laboratory tables, photographic developing trays, etc., and also for many household articles of every-day use. Its only objection seems to be the danger of poisoning presented by the fresh material.

A CABINET IN THE FRED MAY COLLECTION.

It is believed, however, that the poison is merely a volatile acid; and if so, it would seem possible to remove it by the application of heat in some way, so that the quality of the lacquer would remain unimpaired. The antiquity and success of the lacquer industry in Japan at any rate seem to prove that this poisonous quality cannot be so very serious.

The industry appears to have attained the zenith of its fame in the twelfth century during the reign of Emperor Konoye; while even sixteen hundred years earlier, lacquer working was understood by that ingenious race, for history records that during the reign of Emperor Ko-an, four centuries before the Christian era, there was an official known as the "Chief of the Imperial Lacquer Department."

The lacquer tree, known to botanists as *Rhus vernicifera*, is indigenous to Japan, where it grows to a height of twenty-five to thirty feet. The juice exudes from horizontal gashes cut in the bark, the period of "tapping" extending from April to the end of October. In the spring it is more watery than in the later months. The "collector" uses a pointed spoon-shaped instrument, from which the juice is transferred to a wooden receptacle or tube of bamboo. Several cuts are made in each tree, the uppermost being about as high as a man can reach. The greatest yield of a single tree in a season is from forty to fifty cubic centimeters of raw lacquer. When the sap first exudes, it is a grayish-white thick fluid, which quickly turns yellow; and later, black, if exposed to the air. In this state the sap is called Ki-urushi, this being the general name indeed for lacquer. It is strained through cotton cloth to free it from particles of wood and dirt, first being thoroughly stirred so as to break up lumps and make a uniform mixture. From the raw material many kinds of lacquer are made, differing both in quality and color. Cinnabar is added in order to produce red lacquer; orpiment and indigo mixed, to produce green lacquer; orpiment alone for yellow lacquer, etc. As it comes from the tree, the emulsion has been described as consisting of an aqueous fluid holding in suspension numerous very minute brown globules and a smaller proportion of lighter colored and larger globules. The former are insoluble in water, but soluble in alcohol, while the latter can be dissolved in water.

To describe the variations in the composition of the different kinds of lacquer would be manifestly impossible in a brief article, but a few of them may be mentioned. Thus "Ro" is the black product, made by adding to the pure lacquer a liquor formed by steeping iron filings in vinegar and exposing them to the sun for a few days. "Muritate" is pure lacquer mixed with water that has been poured on a whetstone, to which is added a little powdered turpentine. "Johana" lacquer has a little oil from the "Ye" plant in addition to the water and turpentine. "Makanuni" is pure lacquer from which all the water has been extracted. "Seshime" is a mixture of pure lacquer with finely powdered charred wood and a glaze made from seaweed. "Ki-seshime" is made from the lower branches of the tree or from the branches of old trees that have been cut down. Again, different qualities of lacquer are used for special purposes, and most of the famous pieces of lacquer ware are examples of one of the following kinds:

Polished Black Lacquer: upon which appear figures, landscapes, patterns, etc., painted in gold lacquer in very slight relief, sometimes diversified by diminutive square bits of gold foil, laid either on the black ground, on the gold pattern, or on both.

Sprinkled or "Aventurin" Lacquer: the ground of which is sometimes of an uniform sprinkle of gold, and sometimes in clouds or clusters.

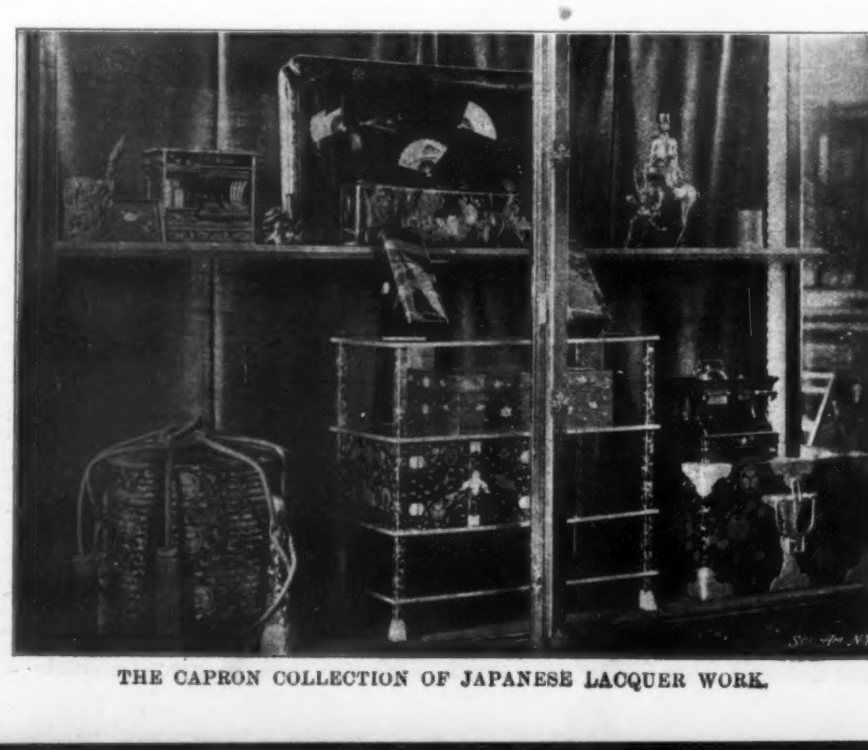
Gold Lacquer: which is practically the same as the last, only made with so fine and dense a sprinkle as to resemble a dull metallic surface.

Smooth Polished Lacquer: in which the pattern, which may be elaborate with flowers and figures, looks as if it had been stained on the brownish ground.

Mokume, or Wood-Grain Lacquer: in which the whole ground is covered with veins arranged like those of wood, and varied by different densities and colors of gold sprinkle.

Then there is opaque red-ground lacquer, pearl-sprinkled lacquer, marbled lacquer, and branched or sprigged lacquer, transparent lacquer, which latter is

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.



THE CAPRON COLLECTION OF JAPANESE LACQUER WORK.

a mere varnish, although exquisitely hard and brilliant, and many other varieties.

The wood generally used by the Japanese for lacquer work is prepared from a coniferous tree named *Chamæcyparis obtusa*. It is prepared in various ways, according to the class of work on hand. In the manufacture of Wakasa ware, which has been so well described by Mr. Romeyn Hitchcock, the wood is first carefully smoothed, the corners of the box (which we will suppose to be the object to be lacquered) being strengthened by gluing pieces of cotton or hemp cloth around them with raw lacquer. All joints and imperfections are then filled up with a kind of putty called *tsugi urushi*. The box is then covered with *jinoko*, which is a cheap grade of lacquer mixed with a coarse yellowish powder. The box is now left in the open air for a few days, to allow some of the water to evaporate, after which it is placed in a moist air-closet to harden. By this process a very hard, gritty surface is obtained, affording an excellent ground for the succeeding coat. Next come two applications of lacquer, containing a fine powder—a kind of ocher used much in Japan for cleaning and polishing. An extra coat is spread over the joints. The surface is then rubbed down with a stone called *toishi*. From this point the treatment of the parts to be decorated and the parts not to be decorated, differs. The latter are ready for the finishing applications. The other parts, i. e., those which are to be decorated, are next covered with a black lacquer, *naka muri urushi*, followed by two more coats, the first (*roiro*) being put on with a broad brush. This dries with a brilliant reflecting surface. When quite hard, the second coating is given, and it is on this, while still soft, that the designs are *impressed*.

In Wakasa lacquer (and this is the kind now being described) there is no painting or drawing, but the figures are produced in a very curious manner. The white decoration is applied by dropping egg-shell powder in particles here and there. This is done by hand. Other designs are made by pressing various forms of leaves into the soft surface, while diverse effects are produced by scattering over the surface husks of rice, mingled with very short pine needles. Mother-of-pearl from shells is also used in decorating.

The impressions thus made are retained in the lacquer, and after the leaves, etc., have been imbedded for about a day, everything except the eggshell powder and mother-of-pearl is removed. The box is again put in a moist closet until the lacquer becomes thoroughly hard, which may require ten to fourteen days. The eggshell application is now in little heaps, while the leaf impressions are beneath the general surface. It is necessary to fill up all depressions and once more secure an even surface. This is effected by rubbing down and applying several more coats of lacquer. After that, a transparent lacquer, colored yellow with arsenic sulphide, is applied. This is spread as evenly as possible, so as to afford a yellow ground for the gold. After the whole has been completely covered with gold leaf, several more coats of transparent red lacquer are added, till the surface is quite even. This is now uniformly black, and beneath it the gold and other decorations are concealed. Further rubbings with *toishi* or *sai kido* are in order until the designs again become visible, the pattern now being revealed in gold, with the pure white of the eggshell powder to relieve the effect. A final rubbing is next given with a special kind of charcoal, known as *hozumi*, producing an excellent surface. But in order to make it more brilliant, it is covered with a finishing coat of very fine lacquer, called *tsuya urushi*. This completes the operation.

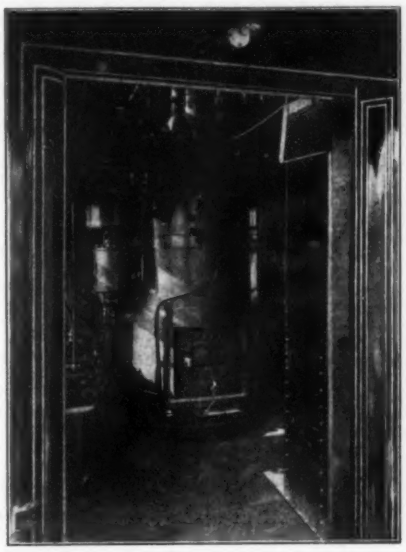
The illustrations used in connection with this article show some celebrated lacquered objects in the famous Capron and Fred May collections on exhibition in the National Museum at Washington.

PRACTICAL AIR-BRAKE INSTRUCTION FOR RAILROAD MEN.*

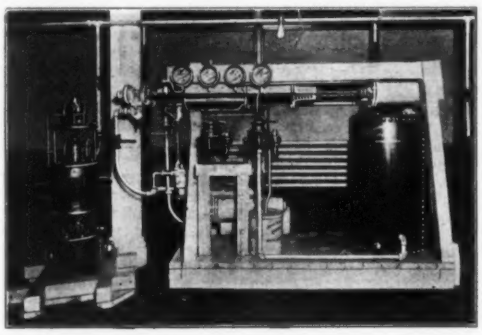
THE International Correspondence Schools, of Scranton, Pa., employ, in conjunction with the regular instruction papers and colored, built-up charts used in their railway courses, special instruction cars fitted with all the air-brakes and similar apparatus used on a complete train. These cars are sent from place to place, and form traveling lecture and demonstration rooms for students in different places. Over 30,000 men interested in railroading are at present enrolled in the railway courses, and 112 of the railway companies have agreements with the schools for the instruction of their employés.

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

At present, the air-brake cars in use are six in number. Three of them are about 74 feet in length, and have a complete air-brake equipment for a train of 50 cars installed upon them, all operated and connected as in actual practice. With these, there is the regulation engine-and-tender brake equipment for two engines, together with all necessary piping, brake valves, gages, reservoirs, etc. These are so arranged as to permit of demonstrating the action of air brakes both with single engine and double-headed. Cut-out cocks are so situated that any brake or brakes can be cut out of the system, so as to make the conditions equivalent to that of a mixed train containing cars with and without air brakes, or to that of a train shorter than the one provided for. The piping is of the same length as occurs in actual practice, that for each car being looped behind the corresponding brake mechanism. One car is so equipped as to permit of the insertion of the New York triple valve in place of the Westinghouse, to such extent as may be desired in showing the working of either type alone or in connection with the other. Sectional models of engineers' brake valves, triple valves, brake cylinders, and auxiliaries are connected in tandem with live apparatus, thus showing the actual operation and the interior arrangement at the same time. Sectional air pumps are also operated in tandem with live pumps of the same kind. Pressure gages are attached to cylinders and auxiliaries at intervals throughout the length of the train to show more clearly the progressive action of the brakes from end to end of the train. Defective triple valves are located at different points in the train, in order that their effect upon the brake action may be clearly seen. In fact, everything that is to be taken into account in the make-up and handling of air-brake trains can be plainly illustrated through the manipulation of this apparatus.

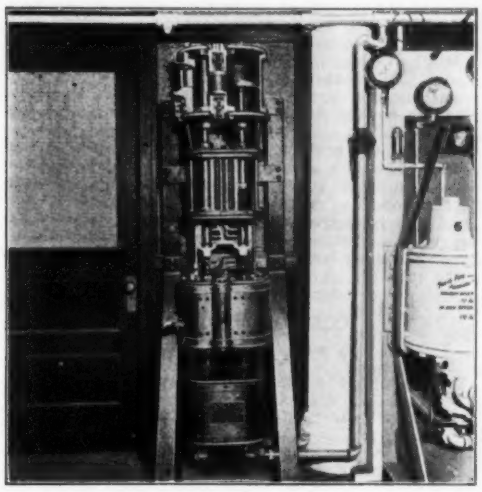


BOILER AND AIR PUMP AS PLACED IN CAR.



WESTINGHOUSE ENGINE AND TENDER EQUIPMENT, SHOWING LINE AND SECTIONAL APPARATUS CONNECTED IN TANDEM.

These three cars also carry sectional injectors of the different makes, neatly arranged on pedestals.



LINE AND SECTIONAL NEW YORK AIR PUMPS OPERATING IN TANDEM FOR DEMONSTRATION PURPOSES.

Lubricators, steam-heat valves, pop safety valves, steam gages, bell ringers, sanding devices, and extra brake and triple valves are kept on hand, sectioned in such a manner as to best show their interior arrangements and workings. Along the ceiling of the cars run piping and hose connections for a ten-car air-signaling equipment.

On three smaller cars the brake equipment is only for 32 freight cars. A working model American-type locomotive (scale of 1 inch to 1 foot) is mounted in each of these cars. This engine is run by compressed air, and can be used to illustrate many points in regard to valve actions, link motions, etc. A regular valve-motion model is also to be seen on each car. All three cars have a boiler room at one end, equipped with a vertical boiler for supplying compressed air and heat. A 9½-inch Westinghouse pump is operated alongside of the boiler, and a sectional model of the same pump is out in the main aisle of the car, so connected as to work in tandem, and so situated that the class may see its operation without losing sight of the parts of the equipment. One car has a No. 2 New York air pump in addition to the 9½-inch Westinghouse pump. A No. 1-A Ohio injector feeds the boiler, and a small duplex Worthington pump may be used either separate from or in connection with the injector. A No. 3-A Detroit lubricator oils each of the air pumps and the Worthington.

A water supply of 600 gallons is carried in two tanks, located under the car, and lagged and jacketed to prevent freezing. The coal box, in the boiler room, holds one ton.

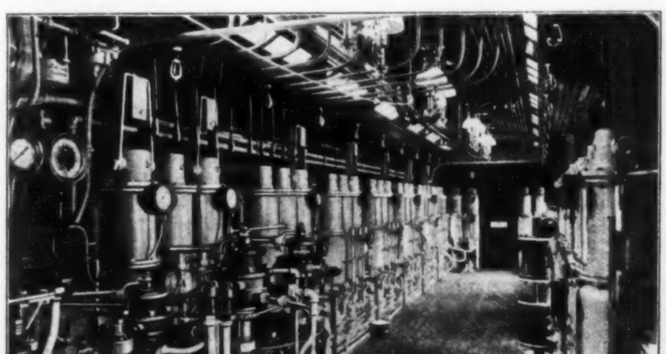
A Baker heater with McElroy commingler, which can use fire or steam from the boiler, heats the car.

Between the boiler room and the instruction room is a kitchen, a dining room, and an office. Sleeping accommodations for four air-brake men, a cook, and a porter are provided.

A screen for stereopticon-lecture purposes is attached to the ceiling of the instruction room in such manner that it may be rolled up like a window shade. In the stereopticon equipment are included colored slides which show all parts of the locomotive, its attachments, air-brake parts, etc., in such a manner as to show many points that cannot as well be understood from the models. Slides for something like 1,200 or 1,300 separate pictures are carried on each of the six cars.

A Pyle-National electric headlight equipment, in-

INTERIOR OF AIR-BRAKE DEMONSTRATION CAR, CONTAINING EQUIPMENT FOR FIFTY FREIGHT CARS.



INTERIOR OF AIR-BRAKE DEMONSTRATION CAR, CONTAINING EQUIPMENT FOR FIFTY FREIGHT CARS; SHOWING BRAKE VALVES IN THE FOREGROUND.

cluding both dynamo and light, is mounted on each car. Each car can be lighted by either oil or electricity, forty-six 16 candle power incandescent lamps being provided, as well as seven double Acme oil lamps for use where current cannot be obtained. The foundation brake of each car is equipped with a high-speed reducing valve and McKee slack adjuster.

These six cars, together with twelve that are equipped for combined instruction and lecture demonstrations, are constantly touring the various railroads, and instructing their employes, demonstrating the value and the manner of the instruction to railroad men generally. Each car is accompanied by practical railroad men of established reputation in their respective lines, who deliver the lectures and demonstrate the apparatus. Opportunity is given to all who so desire to investigate and settle misunderstood points by direct reference to and handling of the working and sectional models.

As all of the equipment found on these cars is representative of the most approved railway practice, the instruction given is of great practical value. By employing portable, rather than resident, plants of sectional and operative air-brake and other railway apparatus, the instruction from actual models can be given to a much larger number of students in all parts of the country.

COSMIC EVOLUTION.*

By PROF. A. W. BICKERTON.

IN this paper the term galactic system will mean not only the Milky Way, but also the caps of nebulæ at its poles. The term Milky Way will be used to imply the galaxy itself. The term cosmic system will be applied to aggregations of dimensions comparable to the Magellanic clouds and to our own galactic system. (In my earlier papers these masses were called universes; but Lord Kelvin and Lord Rayleigh independently pointed out that this name might mislead. I have consequently substituted cosmic systems.) The term cosmic system of the first order applies to aggregations without definite structure, in which no general collision has occurred. In systems of the second order, a single general collision has taken place, and the symmetry is perfect. All other cosmic systems are of the third order. In these more than one general collision has occurred, and there is too much symmetry to be of the first order, and too little symmetry to be of the second. The visible universe (the galactic system of which our solar system is a part) is consequently a system of the third order.

The group of recently-discovered monatomic elements that have no combining power, namely, helium, neon, argon, crypton, and xenon, I call cosmic pioneers. They are practically always independent atoms, and probably play an important part in laying the foundation of an incipient cosmic system, helium being the most important. Possibly these elements have no other function than this, as deductions from their properties suggest that they must largely pass out of cosmic systems before the system matures. Hydrogen plays the same initial part, but it is more than a cosmic pioneer; it has important functions in cosmic systems of all orders.

This paper is chiefly devoted to grazing and whirling collisions of celestial bodies.

Grazing collisions of stars were discussed before the Royal Society by Dr. Johnstone Stoney more than thirty years ago. The formation of double stars and new stars by such an occurrence was suggested by him, as well as the probability of the existence of dead suns in countless hosts.

The especial point I wish to forward is that a grazing impact will generally result in the formation of a new body, while the two struck stars proceed on their journey; as it were, flint and steel have struck and have cut off a part from each other, that results in an intensely heated spark.

Because the non-colliding parts are but little affected by the collision I call such a phenomenon a "partial impact."

With stars of the same order of dimensions that our sun has, the velocity developed by mutual attraction will be hundreds of miles a second. When by impact this motion is converted into heat in the coalesced parts, the temperature will be practically the same, whatever the amount struck off; if the graze be small, the attractive power of the new body will also be small, and it is evident that the velocity of the molecules may be great enough for every molecule to have more than the critical velocity; each molecule as it reaches the surface will consequently leave the body, never to return.

The temperature may easily be from ten to a hundred million degrees Centigrade. It will of course vary with the chemical composition.

Thus is produced in less than an hour a fiery mass expanding about a million miles an hour, and this increase in size will cause for a time an increase in brilliancy. Presently, however, the radial direction of the molecules will tend to cause their motion to become parallel, and will lessen the number of molecular encounters, and consequently the amount of radiation, so that after a time our bright star becomes a planetary nebula. In a year or so each molecule is wandering alone; the brilliant body and the nebula are gone. The body has lost its light, not by cooling, but by being too hot to hold together.

The two stars that struck have been heated where they were sheared, and they are separating at a speed of hundreds of miles a second. Hence the spectrum of our nova is made up of a continuous spectrum, with broad, bright, indistinct bands produced by the expanding gas, and on this band are superimposed two other lines, bright or dark, dependent on the position from which we view the lake of fire produced by the impact.

Obviously the tangential retardation will cause rotation, and the cut stars may alternately show their light and dark faces. Thus two variable stars are produced at once; generally this variability will tend to die out more quickly in one than in the other, yet there are many such pairs still existing.

It is certain that such pairing is not the result of chance. Whatever the explanation offered to account for variable stars must account also for the existence of pairs.

The middle body attracts and retards the escaping stars, and may wed them into pairs.

Then, were no other agency to come into play, the pair would return to impact again, but long before they attain aphelion distance the central mass (consisting as it does of gas above the critical velocity) will have fled into space.

Hence the only force that attracts the stars back again is their own mass, and consequently, instead of colliding, the stars move in the ordinary double-star orbit. Double stars, when first connected, would be variable, and would be associated with nebulæ; this is actually the case, and any satisfactory account of double stars must explain these facts.

If the two stars had had a considerable proper motion they would not have been orbitally connected, and they would constantly increase their distance from each other.

This is doubtless the condition of the unassociated variable stars that are in pairs, and it is possible that their increase in distance could be observed.

Supposing too much had been cut off and coalesced, and the attraction were consequently too great for the heat to give *every* molecule more than its critical velocity; on attaining equality of temperature the light atoms would rob the others of their energy and escape.

Hydrogen at the same temperature has sixteen times the tendency to escape that oxygen has, and two hundred and eight times that of lead. This tendency of the chemical elements to sort themselves I call "selective molecular escape."

Hence at every cosmic impact of dense bodies some light molecules leave with such extreme velocity as to escape not merely the mass, but the galactic system altogether. These molecules wander in space, perchance to other cosmic systems.

Another agency is at work giving motion to free molecules. Radiant energy is caught by cosmic dust of all dimensions. Sir W. Crookes' experiments on "Radiant Matter" suggest that free molecules do not take up or give out radiation. (Dr. Johnstone Stoney has lately suggested to me that this point is unimportant, as even should the molecules absorb radiation, this energy will increase the velocity of the succeeding rebound.) But when slowly moving light molecules touch this heated dust, it will bound off in the same way that molecules fly with increased velocity from radiometer vanes. Thus radiant energy is converted into heat, and this into potential energy.

There are other agencies by which light atoms are liberated from cosmic systems to wander indiscriminately. Such atoms do work against the attraction of systems, and where potential is highest they move slowest.

Where they thus linger they tend to accumulate. The potential of this part of space lessens, and the work required to reach these positions not being so great as at first, oxygen and other heavier molecules get there, increasing the density; and oxygen also tends to produce non-volatile compound molecules.

These would coalesce; but helium and the other cosmic pioneers do not combine, they remain permanently gaseous. Thus a primary cosmic system is incipient. Dense bodies sent out of cosmic systems by the interaction of three bodies would generally pass through old cosmic systems where matter is in dense masses, but evidently not through such vast gaseous aggregations as the incipient cosmic systems. The bodies would be retarded by the friction produced, and perchance volatilized, forming nuclei in the general mass; their mutual attraction would cause denser aggregations to occur, and a cosmic system of the first order would be produced. Two such systems colliding produce a system of the second order. This, colliding with any other cosmic system, produces a system of the third order. Our own galactic system is very probably a tertiary system.

The kinematic condition of the impact would exactly produce such a system. It is now known to be a rough double spiral of stars, with sprays and streams of stars and two caps of nebulæ. It is not difficult to picture the kinematic conditions necessary to form such a rough ring, or double spiral of stars with polar caps of nebulous matter.

Let us assume a complete whirling coalescence of two cosmic systems in which the part coming into collision is considerable. This heated part is in the center of the system. Here all the material is volatilized, and the pressure produced can find no relief save axially; hence the system is, as it were, a short cannon open at each end, and the discharged gas spreads itself over the poles of the system.

This discharge, that is commenced by pressure, is finished by molecular escape. Globular nebulæ form in this gaseous matter by the attraction produced by wandering bodies plunging into the gas. The globular nebulæ so produced attract one another and become double nebulæ; they are then wrought into spindles, spirals, dumbbells, or rings by the kinematic peculiarities of the varying depths of impact.

It is significant that temporary stars, planetary nebulæ, and all the bodies likely to be produced by the impact of stars are in the Milky Way; and all the forms of nebulæ deduced as resulting from the impact of nebulæ are where we should expect them to be, namely, at the poles of the Milky Way.

If this generalization represents the mode of nature's action, then there is a possibility that the entire cosmos is immortal, and the present order but a phase of an eternal rhythm.

The sequence of these agencies is as follows:

(1) Diffusion of heat by radiation.
(2) This radiation, falling on the dust of space, heats it.
(3) The heat of this cosmic dust is taken away by slowly moving light molecules having their velocity increased.
(4) Free molecules are also sent out of systems by partial impacts, by selective molecular escape, and other agencies.
(5) Free molecules will remain longest in the position of maximum potential where their motion is least, and will consequently tend to aggregate in the empty parts of space.
(6) By the interaction of three bodies the velocity acquired by one sometimes takes it out of the cosmic system.
(7) Hydrogen and the cosmic pioneers then become a trap for wandering bodies that tend to be stopped and converted into dense nebulæ.
(8) These dense nebulæ tend to attract surrounding gas; they cool and shrink, some ultimately forming solid bodies.
(9) These bodies, by mutual attraction, give density to the new cosmic system.
(10) Such systems are of the first order.
(11) The impact of systems of the first order produces systems of the second order.
(12) Any other impacts produce systems of the third order, of which our galactic system is a type.
(13) The coalescence of two cosmic systems does not necessarily, as a final result, produce a system of a larger mass than one of the two original systems from which it was formed, as many agencies are tending to send matter out of the coalesced mass.
(14) It is thus seen that dissipation of energy is but a part of a complex cyclical process; and there is consequently the possibility of an immortal cosmos in which we have neither evidence of a beginning nor promise of an end, the present being but a phase of an eternal rhythm.

* From the Philosophical Magazine. Communicated by Prof. A. W. Rücker, Sec. R. S.

HYDROCYANIC-ACID GAS AGAINST HOUSEHOLD INSECTS.*

By L. O. HOWARD.

HYDROCYANIC-ACID gas is an excellent remedy for household insects. Probably its first use for this purpose was in June of 1898 by Mr. Marlatt, of this Office, against Psocids in the residence of Mr. G. K. Holmes, of the Division of Statistics of the Department of Agriculture, using the cyanide first at the ordinary strength employed on fruit trees, then double, and finally quadruple this strength. The Psocids came from recently introduced leather-covered furniture, the covering of which was so tightly fastened as to be almost, if not quite, impervious to the gas; and the treatment was only partially successful. Another early use of this gas for household insects was in 1899 in San Francisco by Mr. Alexander Craw, Chief Quarantine officer of the Board of Horticulture. In this case it was used against bedbugs, and in very small proportions. Two and one-half fluid ounces of commercial sulphuric acid and 2½ ounces of 98 per cent cyanide of potassium were used in a house of several rooms, each containing about 2,250 cubic feet of space; the rooms were closed for two hours, then entirely aired. The operation was apparently successful.

To determine its availability against the insect enemies of stored products or in granaries, some experiments were made during 1898 and the spring of 1899 by Messrs. Marlatt and Chittenden, of this Office, in the presence of D. G. Fairchild and others, against certain grain weevils and the Angoumois grain moth, but with imperfect success, although the proportions used were much greater than in Mr. Craw's experiment. In his recent book on fumigation methods, Prof. W. G. Johnson states that he used the hydrocyanic-acid gas in a granary and storehouse in June, 1899, using it at the rate of 0.1 gramme of cyanide per cubic foot of space. The granary was affected by weevils, and, from the report of the owner, it appears that most of them were destroyed, though many escaped. During the same month in an Ohio mill another experiment of this kind was carried on under Prof. Johnson's instructions. The owner considered the experiment to be a most grand success. The Mediterranean flour moth and certain granary beetles were destroyed.

Perfectly successful experiments were made, however, during the summer of 1901 by Mr. W. R. Beattie, of the Department of Agriculture, and by Mr. A. H. Kirkland, of Boston, Mass., formerly Secretary of the Association of Economic Entomologists. Mr. Beattie's experiments were against cockroaches, and Mr. Kirkland's in one case against fleas and in the other against clothes moths.

Entomologists have long since noticed that insects vary greatly in their susceptibility to cyanide fumes. The ordinary killing bottle used in making collections contains cyanide of potassium covered with plaster of Paris, which the fumes of the cyanide penetrate. Certain weevils, and especially such weevils as Lixus and Sphenophorus and other hard-bodied forms, will frequently be left overnight in a cyanide bottle and recover after being removed. It has been noticed, also, that in greenhouses certain insects recover. The experience gained, however, indicates that the use of hydrocyanic-acid gas in houses is successful against cockroaches, bedbugs, clothes moths, ants, white ants, house flies, and other soft-bodied insects; and as these constitute the majority of the household pests, the use of the gas must now be considered a standard remedy. Moreover, rats and mice are also killed by its use.

Some entomologists recommend as a substitute for hydrocyanic-acid gas a substance which has been more or less effectively used, viz., carbon bisulphide. The great danger in the use of this latter substance, however, from its extreme inflammability and explosiveness of its vapor when confined, renders it, perhaps, less available and more than counteracts the danger to human beings from the use of the hydrocyanic-acid gas.

Recent experience indicates that in order to destroy the household insects mentioned, one fluid ounce of commercial sulphuric acid, diluted with two fluid ounces of water, to increase the bulk of the liquid and insure complete chemical action, and one ounce of high-grade (98 per cent) cyanide of potassium must be used for every 100 cubic feet of space.

* Circular 46, United States Department of Agriculture.

Before performing the operation the house must be vacated, and it is well to do this just before nightfall. It is not necessary to remove any of the furniture or household belongings unless of polished nickel or brass, which may tarnish a little. Liquid or moist foods, as milk or other larder supplies that are not dry and might absorb gas, should be removed from the house. All fires should be put out, for, while the gas will not burn under ordinary conditions, it is well to take no risks.

On the floor of each room should be placed a large porcelain wash basin, and into each wash basin should be poured the proportionate amount of water and sulphuric acid. It may be well to place under each wash basin a thick layer of newspapers, in order to avoid damage to carpet or rugs by the possible spattering of the acid acting upon the cyanide. All windows must be closed, and if they are not tight they should be calked with thin paper or cotton batting. Then the operator, beginning at the top of the house, drops the proportionate amount of cyanide of potassium, previously weighed out into thin paper sacks, into each washbowl, running rapidly from room to room and instantly closing the door behind him, descending ultimately to the ground floor or even to the cellar, running finally into the open air through the open door, which is instantly closed.

Hydrocyanic-acid gas is lighter than air and consequently rises. Therefore, the operation must be begun at the top of the house. The next morning the operator returns to the house, opens the last door, allows a certain amount of airing; then enters hurriedly and opens the windows of the first room or floor; then, after the thorough airing of this one, another in turn, thus gradually airing the whole house. The fumes quickly overcome and are fatal to human beings; hence the necessity for the utmost care and greatest speed in the initial operation and in the subsequent airing and the undesirability of performing the experiment alone. The house should not be reinhabited until all trace of the odor of the gas has disappeared. This odor resembles that of peach kernels.

The experience of Mr. Marlatt and Mr. Kirkland indicates that the operation can be safely performed in the manner indicated, but there is another way which was originally invented in greenhouse work. An ingenious person, by means of strings and improvised pulleys, can arrange it so that standing outside and loosening the string the cyanide suspended over the receptacles may be dropped simultaneously into the sulphuric acid. It will be, perhaps, not necessary to go into details, since any ingenious person can devise such an arrangement. It is, however, not so certain as dropping the cyanide by hand, since a caught string here or there might lessen the completeness of the fumigation.

While the writer must again emphasize the dangerous and even fatal qualities of this gas when breathed by human beings, it is worthy of remark that in the thousands of operations which have been carried on with this gas in specially constructed houses for the fumigation of nursery stock in different parts of the country, no cases of fatal accident to a human being have ever been recorded. In one instance mentioned by Prof. W. G. Johnson, a careless negro was overcome by the gas and was removed from the inclosure (dragged out by the feet) before serious results followed.

It follows, from what we have just said, that there may be danger from fumigating one house in a row of houses separated only by party walls, the other houses being inhabited. Unnoticed cracks in a wall would admit the poisonous gas to the neighboring houses. In such a case a householder must consult his neighbors. In isolated houses, however, with the precautions indicated, the operation will be a safe one. The fact that Mr. Kirkland observed that English sparrows resting on the ridge of one of his houses were killed by the ascending fumes indicates, also, that where the house to be operated upon immediately adjoins a higher structure to which the gas may possibly gain entrance, there may be some danger to the occupants of the higher structure.

Subsequent to the preparation of the foregoing portion of this circular a large dwelling house in Washington, D. C., was fumigated under the direction of Mr. Marlatt, and the following notes, based on this experience, are appended to more fully illustrate the fumigation process. The house was a fairly good-sized one, and all five floors, counting the garret and the basement, were treated, the space representing nearly 40,000 cubic feet and requiring the use of some 25 pounds of cyanide and a corresponding quantity of acid.

The cubic contents of each room on each floor were carefully computed, and a tabular statement, given below, was prepared designating for each floor and the different rooms the capacity and the amount of water, acid, and cyanide needed.

TABLE DESIGNATING ROOMS, CAPACITY, AND AMOUNTS OF CHEMICALS.

Floor.	Room.	Cubic feet	Water.	Acid.	Cyanide.
			Fl. oz.	Fl. oz.	Avd. oz
Fourth	Garret	*7,000	150	70	70
Third	Front	2,800	56	28	28
	Middle	1,400	28	14	14
	Back	2,200	44	22	22
Second	Front	*5,500	110	55	55
	Middle	2,200	44	22	22
	Back	2,000	40	20	20
First	Parlor	*4,400	88	44	44
	Middle	2,400	48	24	24
	Dining	2,900	58	29	29
Basement	Servants'	1,200	24	12	12
	Hall	2,000	40	20	20
	Kitchen	1,800	36	18	18
Total		39,800	756	378	378

* The charges for these rooms were halved and set off in two vessels.

The rooms were prepared for treatment by seeing that all windows were closed and that the doors and windows of the ground floor were left unlocked or unfastened, so that they could be opened from without. The fireplaces in the different rooms were stuffed with paper and the registers were all closed. The carpets and rugs, where possible, were cleared away from the floor to prevent their being burned should the acid spatter out or boil over, and a large porcelain wash-basin or a porcelain waste jar was put in each room, two such vessels being placed in the larger rooms. Under each a carpeting of old newspapers was placed. A number of vessels had to be discarded because of cracks, which would be dangerous in view of the heat generated by the process.

The house having been put in a state of readiness for the experiment, and the vessels for the charges having all been placed in their proper locations, the requisite amount of water indicated by the table already prepared (twice the amount of the acid) was poured into each of the different vessels. Following this, the proportionate amount of acid for the different rooms was added to the water in the vessels, the addition of the acid developing a high temperature. The cyanide having been previously weighed out in half-pound lots and put in small thin paper bags, was distributed through all the different rooms in the proper amounts. The division of the bags for the fractional weights was made at the time the bags of cyanide for each charge were placed by the side of the vessels to receive them. The house was now in readiness to be fumigated. Coats and hats and everything needed outside were removed, and two persons went to the garret of the house and quickly placed the bags of cyanide in the already combined water and acid, passing rapidly down to the next floor and repeating the operation, and so on until the basement was finished and the escape was made from the basement door to the street.

The preparation of the different rooms, getting their cubic contents, fixing the vessels, and preparing the charges consumed in a house of this size nearly three hours. The gas was left to do its work for three hours longer. The house was then opened cautiously, the doors and windows of the lower floor first, then proceeding by easy stages through the different floors to the garret. The gas coming out of the house when the first doors and windows were opened was in enormous volume, showing that the house had retained it very effectually, and escaping from the house it was distinctly recognizable by its odor at a distance of over half a block. The windows of the adjoining houses were kept closed during the process of airing out. One of the assistants who attended to the aerating of the house was rather too precipitate in going to the upper rooms and breathed more or less of the gas, but suffered no worse result than a rather severe headache, which lasted for several hours.

The results of the fumigation were eminently satisfactory; no living insects could be found in the house. The roaches, by thousands, had come out from their hiding places in a vain effort to escape, and had rushed to the cracks under doors and windows, and had there perished. Sometimes they had the appearance of being alive and about to run, and a touch was necessary to demonstrate that they were dead, having been arrested instantly while in motion, their limbs extended in the normal position for running. Flies, roaches, and bedbugs, and without doubt all the other household pests, were killed. The bedbugs, against which the fumigation was especially directed, were found dead in numbers under trunks and about the beds.

The ingredients used were the 98 per cent cyanide of potassium, costing about 40 cents a pound. The sulphuric acid was the thick, almost sirupy commercial brand, costing about 4 cents a pound, the total cost of the materials used being, approximately, $12.

In handling the acid great care should be used in pouring it from the bottle and in putting it into the vessels to avoid spattering on the hands or face, since it will burn rapidly through the skin, and should it spatter into the eyes would cause serious inflammation, or if on the clothing it would burn a hole in the garment. Should a drop fly to the hands or face, bathe the part promptly and freely in water, and the same also for garments or the carpet. It is further desirable to have at hand a bottle of ammonia water to neutralize the acid should it spatter on the clothing. The cyanide should be broken up into lumps not exceeding twice the size of a walnut, the powdered and smaller fragments serving equally well.* The bags should be of very thin paper. If they are of thick, heavy paper, the action of the acid is delayed, and sometimes prevented completely. If there is any danger of this make two or three slits in the bottom of the bags to facilitate the entrance of the acid. Deep vessels are more satisfactory for the experiment than the wash basins chiefly used, but the latter were available and required no additional expense and served the purpose. Deeper vessels would give greater depth to the water and acid and accelerate the chemical action. Whenever the room is of such size that more than 2 pounds of cyanide must be employed for it, it is perhaps better to make two charges of half size for such a room. It would have been better, perhaps, in this instance, if the fumigation could have gone on overnight, but the owners of the premises were very desirous of occupying it, and the house was aerated between 4 and 5 o'clock in the afternoon. Three persons, contrary to orders, slept in the rooms during the night, and reported no ill effects, although slight traces of the odor were noticeable in the early part of the night.

The immensity of modern New York is aptly illustrated by a few figures given in an article on New York in Pearson's:

"New York's greatness is shown by the fact that the port of New York transacts a vast proportion of the foreign commerce of the United States; that of letters alone the New York post office handles 897,778,820 annually, and that of the total clearances of the United States, 67 per cent pass through the New York Clearing House, the amount being $79,420,000,000.

"The police force of the Borough of Manhattan is 4,546. The chief of the Fire Department writes that the fastest time ever made in getting ready to respond to a fire call was 1⅘ seconds at an exhibition at Madison Square Garden. The average time is from 2½ to 4 seconds. The Croton and Bronx River systems of water supply have cost about $95,000,000. The length of the aqueducts is 70 miles, and of the distributing mains 886.28 miles. The capacity of the storage reservoirs is 44,700,000,000 gallons; the average daily supply is 275,000,000 gallons, a per capita rate of 134 gallons. The figures are for Manhattan and the Bronx, but mainly apply to the former."

MILNE'S SEISMOLOGICAL OBSERVATIONS AND EARTH PHYSICS.

PROF. JOHN MILNE, the well-known seismological specialist, recently delivered an interesting lecture before the Royal Geographical Society of Great Britain upon "Seismological Observations and Earth Physics," apropos of the various volcanic disturbances in various parts of the world. Prof. Milne pointed out the distinction which exists between macroseisms, or large earthquakes, and microseisms, or small earthquakes. The former he described as world-shaking disturbances, while as regarded the latter, there were about thirty thousand such disturbances every year, each of which disturbs from ten up to several hundreds of square miles of the earth's surface. All earthquakes belong either to the upper or the lower class. When a world-shaking earthquake takes place, and its origin is sub-oceanic, evidence is occasionally obtained showing that this has been accompanied by the bodily displacement of very large masses of material. For example, sea waves may be created which will cause an ocean like the Pacific to pulsate for many hours. The dimension of the mass which was moved—and inasmuch as the displacement was beneath the surface of the ocean, must have been moved suddenly to create an effect of this description—is not known. The observations made by cable engineers, which have shown that in the vicinity of the origin of such earthquakes depths have been greatly increased, and this over a considerable area, enable rough approximations to be made respecting these dimensions. When the effect has extended to shore lines, it is possible to measure definite currents of elevation or depression. With large earthquakes which have originated on land surfaces, the accompanying displacements are visible, and their magnitudes are, to a certain extent, measurable.

Nearly all active volcanoes occur along the ridges of rock folds which are in proximity to oceanic waters. By the percolation of this water to the foundations of these folds, where it comes into contact with a heated magma, extraordinary pressures are developed, the sudden relief of which results in a volcanic outburst. If we accepted a theory of this description, it was easy to imagine a stage when volcanic strain due to an increasing internal pressure was in a critical condition, and therefore likely to be destroyed by any movement in the rock fold where it existed. A good illustration of this relationship between sudden movements in rock folds and displays of volcanic activity was presented by the eruptions in the West Indies and the large earthquakes which have occurred there or in adjacent countries. From the recent geological history of the region it is shown that the Antilles once connected North and South America, while the Isthmus of Panama was submerged, the present Caribbean Sea being therefore a gulf of the Pacific. In Lower or Middle Miocene times, according to Dr. J. W. Gregory, Antillia itself was submerged and abyssal oozes were deposited, which are now elevated in the Barbadoes to a height of 1,095 feet above sea level. In fact, the elevations and depressions of this region had been so great and performed with such rapidity that they had frequently been referred to by the opponents to the theory of the permanence of oceanic basins and continental masses. The most recent movements in the Antilles, as indicated by raised sea beaches, etc., had been upward. The inference to be drawn from the geological history of this region was that the Antillan ridge is one of unusual instability, and it was likely that in consequence of this characteristic it was so responsive to adjustments in neighboring folds.

It is in connection with such regions that seismograms are so valuable, since from these records of earth vibration obtained in epipocal areas, measures of earthquake energy expressed in mechanical units have been obtained. One result of this had been that engineers and builders in earthquake-shaken countries now built to withstand known forces. In Japan it has been repeatedly shown that bridges and buildings constructed according to European practices were unable to withstand the severe shakings which so frequently occur in that country, and, therefore, as opportunity presented itself, the old types of structure were being replaced by forms which experience had proved were not so readily disturbed. The importance of seismology was so far recognized by the Japanese government that at its university are a professor and assistant professor of this subject, whose duties in part consist in giving to students of engineering and architecture, a course of instruction bearing on their future profession. The government also supports a bureau controlling about one thousand stations, and in addition to this they grant an annual subsidy to a committee, consisting largely of practical men, whose duty consists in making investigations which would lead to the mitigation of earthquake effects. Not only does this body investigate destruction which from time to time occurs in Japan, but should a disaster take place in Manila, India, or some distant country, a commission is dispatched to report on that which fell and that which remained intact. By this means Japan has become a repository for almost all that is known about applied seismology, which has already been the means of saving life and property. Seismograms of unfelt earthquakes not only explain certain irregularities in magnetograms, but they also threw light on abnormal movements in the records from electrometers and barometers. Apparent changes in the rates of timekeepers have frequently been traced to earth movements, the occurrence of which could not be suspected without the aid of seismograms. It has often happened that cables have been

destroyed by submarine earthquakes, and to know the causes of such interruptions is of great importance, especially to communities who have by such occurrences been suddenly isolated from the outer world. The breaking of cables in certain instances has been regarded as an operation of war, with the result that military and naval preparations have been made, expenses of various descriptions incurred, and naturally much alarm caused, all of which would have been avoided by the inspection of a seismogram. These records enable us to locate submarine sites where it would be rash to lay a cable. Lastly, they enable us to confirm, correct, extend, and occasionally to disprove messages that have been received by cable describing seismic catastrophes in distant countries.

RECENT STUDIES IN GRAVITATION.*

By Prof. JOHN H. POYNTING, D.Sc., F.R.S.

THE studies in gravitation which I am to describe to you this evening will perhaps fall into better order if I rapidly run over the well-beaten track which leads to those studies, the track first laid down by Newton based on astronomical observations, and only made firmer and broader by every later observation.

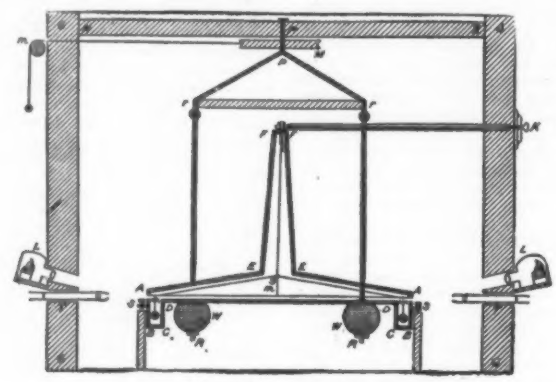


FIG. 1.—CAVENDISH'S APPARATUS.

I may remind you, then, that the motion of the planets round the sun in ellipses, each marking out the area of its orbit at a constant rate, and each having a year proportional to the square root of the cube of its mean distance from the sun, implies that there is a force on each planet exactly proportioned to its mass, directed toward, and inversely as the square of its distance from the sun. The lines of force radiate out from the sun on all sides equally, and always grasp any matter with a force proportional to its mass, whatever planet that matter belongs to.

If we assume that action and reaction are equal and opposite, then each planet acts on the sun with a force proportional to its own mass; and if, further, we suppose that these forces are merely the sum totals of the forces due to every particle of matter in the bodies acting, we are led straight to the law of gravitation, that the force between two masses M_1 M_2 is always proportional to the product of the masses divided by the square of the distance r between them, or is equal to

$$\frac{G \times M_1 \times M_2}{r^2}$$

and the constant multiplier G is the constant of gravitation.

Since the force is always proportional to the mass

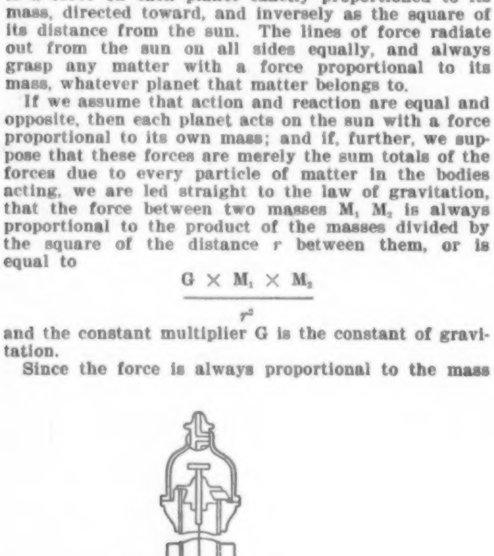


FIG. 2.—BOYS'S APPARATUS.

acted on, and produces the same change of velocity whatever that mass may be, the change of velocity tells us nothing about the mass in which it takes place, but only about the mass which is pulling. If, however, we compare the accelerations due to different pulling bodies, as for instance that of the sun pulling the earth with that of the earth pulling the moon, or if we compare changes in motion due to the different planets pulling each other, then we can compare their masses and weigh them one against another and each against the sun. But in this weighing our standard weight is not the pound or kilogramme of terrestrial weighings, but the mass of the sun.

For instance, from the fact that a body at the earth's surface, 4,000 miles, on the average, from the mass of the earth, falls with a velocity increasing by 32 feet ÷ sec.², while the earth itself falls toward the sun, 92,000,000 miles away, with a velocity of about 1-5 inch ÷ sec.², we can at once show that the mass of the sun is 300,000 times that of the earth. In other words, astronomical observation gives us only the acceleration, the product of G × mass acting, but does not tell us the value of G nor the mass acting in terms of our terrestrial standards.

To weigh the sun, the planets, or the earth in pounds or kilogrammes, or to find G, we must descend from the heavenly bodies to earthly matter, and either compare the pull of a weighable mass on some body with the pull of the earth on it, or else choose two weighable masses and find the pull between them.

All this was clearly seen by Newton, and was set forth in his System of the World (third edition, p. 41).

He saw that a mountain mass might be used, and weighed against the earth by finding how much it deflected the plumb line at its base. The density of the mountain could be found from specimens of the rocks composing it, and the distance of its parts from the plumb line by a survey. The deflection of the vertical would then give the mass of the earth.

Newton also considered the possibility of measuring the attraction between two weighable masses, and calculated how long it would take a sphere a foot in diameter, of the earth's mean density, to draw another equal sphere, with their surfaces separated by one-fourth inch, through that one-fourth inch. But he made a very great mistake in his arithmetic, for while his result gave about one month, the actual time would only be about five and one-half minutes. Had his value been right, gravitational experiments would have been beyond the power of even Prof. Boys. Some doubt has been thrown on Newton's authorship of this mistake, but I confess that there is something not altogether unpleasing in the mistake even of a Newton. His faulty arithmetic showed that there was one quality which he shared with the rest of mankind.

Not long after Newton's death the mountain experiment was actually tried, and in two ways. The honor of making these first experiments on gravitation belongs to Bouguer, whose splendid work in thus break-

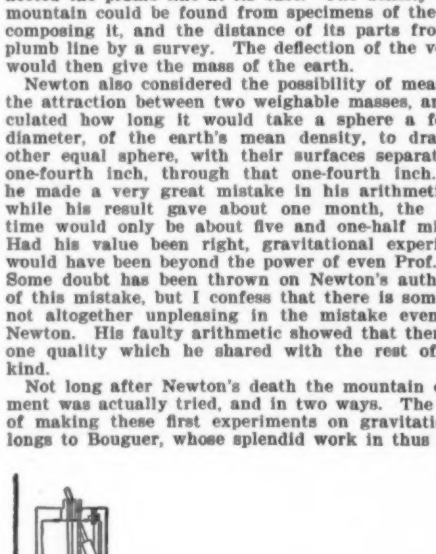


FIG. 3.—COMMON BALANCE EXPERIMENT (POYNTING).

ing new ground does not appear to me to have received the credit due to it.

One of his plans consisted in measuring the deflection of the plumb line due to Chimborazo, one of the Andes peaks, by finding the distance of a star on the meridian from the zenith, first at a station on the south side of the mountain, where the vertical was deflected, and then at a station to the west, where the mountain attraction was nearly inconsiderable, so that the actual nearly coincided with the geographical vertical. The difference in zenith distances gave the mountain deflection. It is not surprising that, working in snow storms at one station and in sand storms at the other, Bouguer obtained a very incorrect result. But at least he showed the possibility of such work, and since his time many experiments have been carried out on his lines under more favorable conditions. Now, however, I think it is generally recognized that the difficulty of estimating the mass of a mountain from mere surface chips is insurmountable, and it is admitted that the experiments should be turned the other way about and regarded as an attempt to measure the mass of the mountains from the density of the earth known by other experiments.

These other experiments are on the lines indicated by Newton in his calculations of the attraction of two spheres. The first was carried out by Cavendish.

In the apparatus (Fig. 1) he used two lead balls,

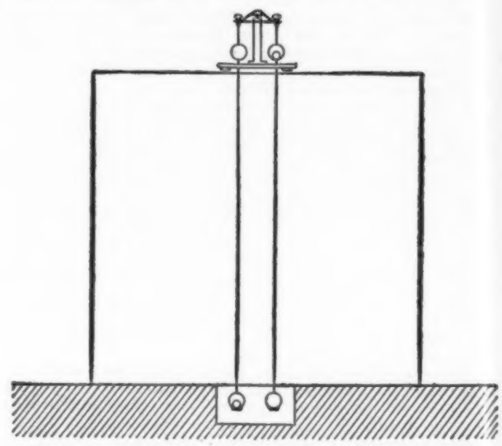


FIG. 4.—COMMON BALANCE EXPERIMENT (RICHARZ AND KRIGAR-MENZEL).

B B, each two inches in diameter. These were hung at the end of a horizontal rod six feet long, the torsion rod, and this was hung up by a long wire from its middle point. Two large attracting spheres of lead, W W, each twelve inches in diameter, were brought close to the balls on opposite sides, so that their attractions on the balls conspired to twist the torsion rod round the same way, and the angle of twist was measured. The force could be reckoned in terms of this angle by setting the rod vibrating to and fro and finding the time of vibration, and the force came out to less than one three-thousandth of a grain. Knowing M_1 M_2 and r, the distance between them and the force $G\,M_1\,M_2/r^2$, of course Cavendish's result gives G, or, knowing the attraction of a big sphere on a ball, and knowing the attraction of the earth on the same ball—that is, its weight—the experiment gives the mass of earth in terms of that of the big sphere, and so its mean density. This experiment has often been repeated, but I do not think it is too much to say that no advance was made in exactness till we come to quite recent work.

By far the most remarkable recent study in gravitation is Prof. Boys's beautiful form of the Cavendish experiment, a research which stands out as a model in beauty of design and in exactness of execution (Fig. 2). But as Prof. Boys has described his experiment already in this theater,* it is not necessary for me to more than refer to it. It is enough to say that he made the great discovery, obvious, perhaps, when made, that the sensitiveness of the apparatus is increased by reducing its dimensions. He therefore decreased the scale as far as was consistent with exact measurement of the parts of the apparatus, using a torsion rod, itself a mirror, only two inches long, gold balls, m m, only ¼ inch in diameter, and attracting lead masses, M M, only 4¼ inches in diameter. The force to be measured was less than $1/5 \times 10^{9}$ grain.

The exactness of his work was increased by using

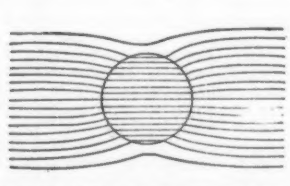


FIG. 5.—PARAMAGNETIC SPHERE PLACED IN A PREVIOUSLY STRAIGHT FIELD.

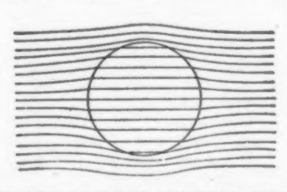


FIG. 6.—DIAMAGNETIC SPHERE PLACED IN A PREVIOUSLY STRAIGHT FIELD.

as suspending wire one of his quartz threads. It would be difficult to overestimate the service he has rendered in the measurement of small forces by the discovery of the remarkable properties of these threads.

* From Proceedings of the Royal Institution of Great Britain, Vol. XVI. Reprinted in the Smithsonian Report for 1901.

* Proc. Royal Institution, XIV, part 2, 1894, p. 353.

One of the chief difficulties in the measurement of these small gravitational pulls is the disturbances which are brought about by the air currents which blow to and fro up and down inside the apparatus, producing irregular motions in the torsion rod. These, though much reduced, are not reduced in proportion to the diminution of the apparatus.

A very interesting repetition of the Cavendish experiment has lately been concluded by Dr. Braun* at Mariaschein, in Bohemia, in which he has sought to

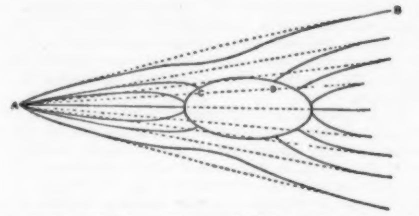


FIG. 7.—EFFECT OF INTERPOSITION OF MORE PERMEABLE MEDIUM IN RADIATING FIELD OF FORCE.

get rid of these disturbing air currents by suspending his torsion rod in a receiver which was nearly exhausted, the pressure being reduced to about one two-hundredth of an atmosphere. The gales which have been the despair of other workers were thus reduced to such gentle breezes that their effect was hardly noticeable. His apparatus was nearly a mean proportional between that of Cavendish and Boys, his torsion rod being about nine inches long, the balls weighing 54 grammes—less than 2 ounces—and the attracting masses either 5 or 9 kilogrammes. His

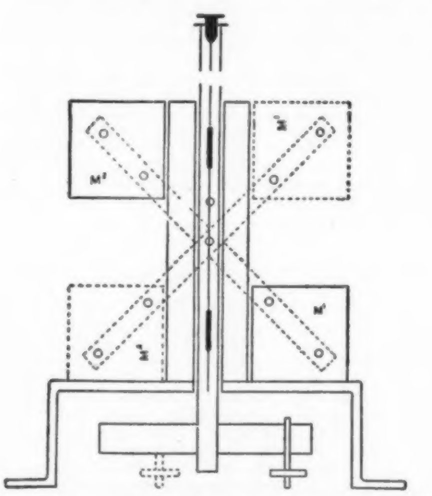


FIG. 8.—EXPERIMENT ON GRAVITATIVE PERMEABILITY (AUSTIN AND THWING).

work bears internal evidence of great care and accuracy, and he obtained almost exactly the same result as Prof. Boys.

Dr. Braun carried on his work far from the usual laboratory facilities, far from workshops, and he had to make much of his apparatus himself. His patience and persistence command our highest admiration.

I am glad to say that he is now repeating the experiment, using as suspension a quartz fiber supplied to him by Prof. Boys in place of the somewhat untrustworthy metal which he used in the work already published.

Prof. Boys has almost indignantly disclaimed that he was engaged on any such purely local experiment as the determination of the mean density of the earth. He was working for the universe, seeking the value of G, information which would be as useful on Mars

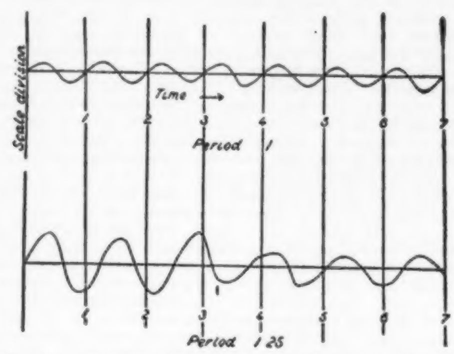


FIG. 10.—UPPER CURVE IN REGULAR VIBRATION. LOWER CURVE A DISTURBANCE DYING AWAY.

or Jupiter or out in the stellar system as here on the earth. But perhaps we may this evening consent to be more parochial in our ideas and express the results in terms of the mean density of the earth. In such terms, then, both Boys and Braun find that density 5.527 times the density of water, agreeing therefore to 1 in 5,000.

There is another mode of proceeding which may be

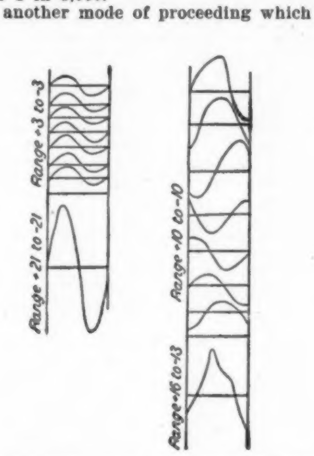


FIG. 11.—RESULTS OF SUPERPOSITION OF LENGTHS OF CURVES IN FIG. 10 EQUAL TO THE PERIOD OF THE REGULAR ONE.

regarded as the Cavendish experiment turned from a horizontal into a vertical plane, and in which the torsion balance is replaced by the common balance. This method occurred about the same time to the late Prof. U. Jolly and myself. The principle of my own experiment* will be sufficiently indicated by Fig. 3. A big bullion balance with a 4-foot beam had two lead spheres, A B, each about 50 pounds in weight, hanging from the two ends in place of the usual scale pans. A large lead sphere, M, 1 foot in diameter and weighing about 350 pounds, was brought first under one hanging weight, then under the other. The pull of the lead sphere acted first on one side alone and then on the other so that the tilt of the balance beam when the sphere was moved round was due to twice the pull. By means of riders the tilt and therefore the pull was measured directly as so much increase in weight. This increase, when the sphere was brought directly under the hanging weight with 1 foot between the centers, was about one-fifth mgm. in a total weight of 20 kilogrammes, or about 1 in 100,000,000. If, then, a sphere one foot away pulls with $1/10^8$ of the earth's pull, the earth being on the average 20,000,000 feet away, it is easy to see that the earth's mass is calculable in terms of the mass of the sphere, and its density is at once deduced. The direct aim of this experiment, then, is not G, but the mass of the earth.

It is not a little surprising that the balance could be made to indicate such a small increase in weight as 1 in 100,000,000. But not only did it indicate, it measured the increase, with variations usually well within 1 per cent of the double attraction, or to 1 in 5,000,000,000 of the whole weight, a change in weight which would occur merely if one of the spheres were moved one-fortieth inch nearer the earth's center. This accuracy is only attained by never lifting the knife edges and planes during an experiment, thus keeping the beam in the same state of strain throughout, and, further, by taking care that none of the mechanism for moving the weights or riders shall be attached in any way to the balance or its case; two conditions which are absolutely essential if we are to get the best results of which the balance is capable.

Quite recently another common balance experiment has been brought to a conclusion by Prof. Richarz and Dr. Krigar-Menzel* at Spandau, near Berlin. Their method may be gathered from Fig. 4. A balance of 23 cm., say 9-inch beam, was mounted above a huge lead pile about 2 meters cube, and weighing 100,000 kilogrammes.

Two pans were supported from each end of the beam, one pan above the other pan below the lead cube, the suspending wires of the lower pans going through narrow vertical tubular holes in the lead. Instead of moving the attracting mass, the attracted mass was moved. Masses of 1 kilogramme each were put first, say, one in the upper right-hand pan, the other in the lower left-hand pan, when the pull of the lead block made the right hand heavier and the left hand lighter. Then the weights were changed to the lower right hand and the upper left hand, when the pulls of the lead pile were reversed. When we remember that in my experiment a lowering of the hanging sphere by 1½ inches would give an effect as great as the pull I was measuring, it is evident that here the approach to and removal from the earth by over 2 meters would produce very considerable changes in weight, and, indeed, these changes masked the effect of the attraction of the lead. Preliminary experiments had, therefore, to be made before the lead pile was built up, to find the change in weight due to removal from upper to lower pan, and this change had to be allowed for. The quadruple attraction of the lead pile came out at 1.3664 mgm., and the mean density of the earth at 5.505.

This agrees nearly with my own result of 5.49, and it is a curious coincidence that the two most recent balance experiments agree very nearly at, say, 5.5, and the two most recent Cavendish experiments agree at, say, 5.53, but I confess I think it is merely a coincidence. I have no doubt that the torsion experiment is the more exact, though probably an experiment on different lines was worth making, and I am quite content to accept the value 5.527 as the standard value for the present.

And so the latest research has amply verified Newton's celebrated guess that "the quantity of the whole matter of the earth may be five or six times greater than if it consisted all of water."

I now turn to another line of gravitational research. When we compare gravitation with other known forces (and those which have been most closely studied are electric and magnetic forces) we are at once led to inquire whether the lines of gravitative force are always straight lines radiating from or to the mass round which they center, or whether, like electric and magnetic lines of force, they have a preference for some media and a distaste for others. We know, for example, that if a magnetic sphere of iron or cobalt or manganese is placed in a previously straight field its permeability is greater than the air it replaces, and the lines of force crowd into it, as in Fig. 5. The magnetic action is then stronger in the presence of the sphere near the ends of a diameter parallel to the original course of the lines of force and the lines are deflected. If the sphere be diamagnetic, of water, or copper, or bismuth, the permeability being less than that of air, there is an opposite effect, as in Fig. 6, and the field is weakened at the end of a diameter parallel to the lines of force, and again the lines are deflected. Similarly a dieletric body placed in an electric field gathers in the lines of force and makes the field where the lines enter and leave stronger than it was before.

If we inclose a magnet in a hollow box of soft iron placed in a magnetic field, the lines of force are gathered into the iron and largely cleared away from the inside cavity, so that the magnet is screened from external action.

Now, common experience might lead us at once to say that there is no very considerable effect of this kind with gravitation. The evidence of ordinary weighings may perhaps be rejected, inasmuch as both sides will be equally affected as the balance is commonly used. But a spring balance should show if there is any large effect when used in different positions above different media or in different inclosures, and the ordinary balance is used in certain experiments in which one weight is suspended beneath the balance case and surrounded perhaps by a metal case or perhaps by a water bath. Yet no appreciable variation of weight on that account has yet been noted, nor does the direction of the vertical change rapidly from place to place, as it would with varying permeability of the ground below. But perhaps the agreement of pendulum results, whatever the block on which the

* Denkschriften der Math. Wiss. Classe der Kais. Akad. der Wissenschaften Wien, LXIV, 1896.

* Phil. Trans. 182, 1891, A, p. 565.

* Anhang zu den Abhandlungen der Königl. Preuss. Akad. der Wissenschaften zu Berlin, 1898.

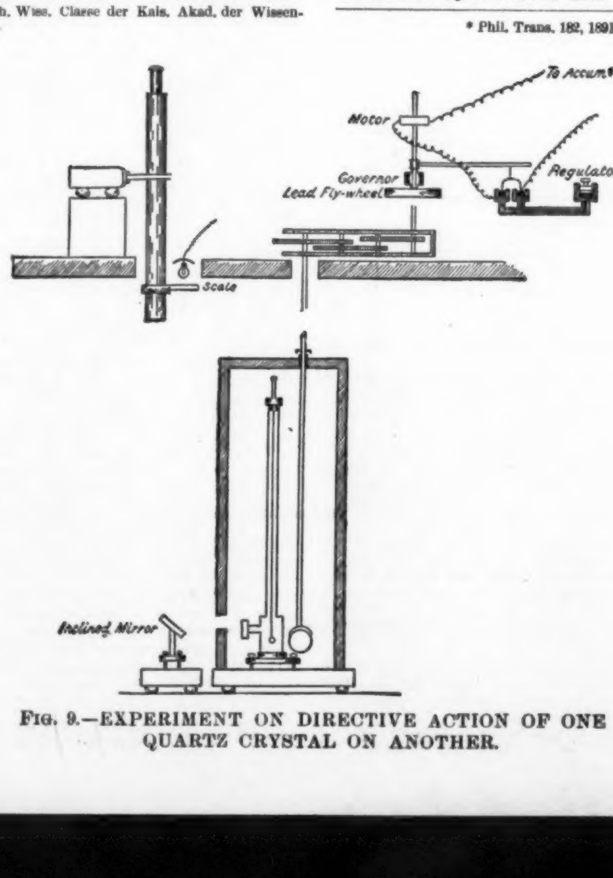


FIG. 9.—EXPERIMENT ON DIRECTIVE ACTION OF ONE QUARTZ CRYSTAL ON ANOTHER.

pendulum is placed and whatever the case in which it is contained, gives the best evidence that there is no great gathering in or opening out of the lines of the earth's force by different media.

Still, a direct experiment on the attraction between two masses with different media interposed was well worthy of trial, and such an experiment has lately been carried out in America by Messrs. Austin and Thwing.* The effect to be looked for will be understood from Fig. 7. If a medium more permeable to gravitation is interposed between two bodies, the lines of force will move into it from each side, and the gravitative pull on a body near the interposed medium on the side away from the attracting body will be increased.

The apparatus they used was a modified kind of Boys's apparatus (Fig. 8). Two small gold masses, in the form of short vertical wires, each 0.4 gm. in weight were arranged at different levels at the ends virtually of a torsion rod 8 mm. long. The attracting masses M, M_1 were lead, each about 1 kilogramme. These were first in the positions shown by black lines in the figure, and were then moved into the positions shown by dotted lines. The attraction was measured first when merely the air and the case of the instrument intervened, and then when various slabs, each 3 cm. thick, 10 cm. wide, and 29 cm. high, were interposed. With screens of lead, zinc, mercury, water, alcohol, or glycerine, the change in attraction was at the most about 1 in 500, and this did not exceed the errors of experiment. That is, they found no evidence of a change in pull with change of medium. If such change exists, it is not of the order of the change of electric pull with change of medium, but something far smaller. Perhaps it still remains just possible that there are variations of gravitational permeability comparable with the variations of magnetic permeability in media such as water and alcohol.

Yet another kind of effect might be suspected. In most crystalline substances the physical properties are different along different directions in a crystal. They expand differently, they conduct heat differently, and they transmit light at different speeds in different directions. We might, then, imagine that the lines of gravitative force spread out from, say, a crystal sphere unequally in different directions. Some years ago, Dr. Mackenzie† made an experiment in America, in which he sought for direct evidence of such unequal distribution of the lines of force. He used a form of apparatus like that of Prof. Boys's (Fig. 2), the attracting masses being calc spar spheres about 2 inches in diameter. The attracted masses in one experiment were small lead spheres about one-half gm. each, and he measured the attraction between the crystals and the lead when the axes of the crystals were set in various positions. But the variation in the attraction was merely of the order of error of experiment. In another experiment the attracted masses were small calc spar crystal cylinders, weighing a little more than one-half gm. each. But again there was no evidence of variation in the attraction with variation of axial direction.

Practically the same problem was attacked in a different way by Mr. Gray and myself.‡ We tried to find whether a quartz crystal sphere had any directive action on another quartz crystal sphere close to it, whether they tended to set with their axes parallel or crossed.

It may easily be seen that this is the same problem by considering what must happen if there is any difference in the attraction between two such spheres when their axes are parallel and when they are crossed. Suppose, for example, that the attraction is always greater when their axes are parallel, and this seems a reasonable supposition, inasmuch as in straightforward crystallization successive parts of the crystal are added to the existing crystal, all with their axes parallel. Begin, then, with two quartz crystal spheres near each other, with their axes in the same plane, but perpendicular to each other. Remove one to a very great distance, doing work against their mutual attractions. Then, when it is quite out of range of appreciable action, turn it round till its axis is parallel to that of the fixed crystal. This absorbs no work if done slowly. Then let it return. The force on the return journey at every point is greater than the force on the outgoing journey, and more work will be got out than was put in. When the sphere is in its first position turn it round till the axes are again at right angles. Then work must be done on turning it through this right angle to supply the difference between the outgoing and incoming works. For, if no work were done in the turning, we could go through cycle after cycle, always getting a balance of energy over, and this would, I think, imply either a cooling of the crystals or a diminution in their weight, neither supposition being admissible. We are led, then, to say that if the attraction with parallel axes exceeds that with crossed axes, there must be a directive action resisting the turn from the crossed to the parallel positions. And, conversely, a directive action implies axial variation in gravitation.

The straightforward mode of testing the existence of this directive action would consist in hanging up one sphere by a wire or thread and turning the other round into various positions and observing whether the hanging sphere tended to twist out of position. But the action, if it exists, is so minute and the disturbances due to air currents are so great that it would be extremely difficult to observe its effect directly. It occurred to us that we might call in the aid of the principle of forced oscillations by turning one sphere round and round at a constant rate, so that the couple would act first in one direction and then in the other, alternately, and so set the hanging sphere vibrating to and fro. The nearer the complete time of vibration of the applied couple to the natural time of vibration of the hanging sphere, the greater would be the vibration set up. This is well illustrated by moving the point of suspension of a pendulum to and fro in gradually decreasing periods, when the swing gets longer and longer, till the period is that of the pendulum, and then decreases again; or, by the experiment of varying the length of a jar resounding to a given fork, when the sound suddenly swells out as the length becomes that which would naturally give the same note as the fork. Now, in looking for the couple between the crystals, there are two possible cases. The most likely is that in which the couple acts in one way while the turning sphere is moving from parallel to crossed, and in the opposite way during the next quarter turn from crossed to parallel; that is, the couple vanishes four times during the revolution, and this we may term a quadrantal couple; but it is just possible that a quartz crystal has two ends, like a magnet, and that like poles tend to like directions. Then, the couple will vanish only twice in a revolution and may be termed a semicircular couple. We looked for both, but it is enough now to consider the possibility of the quadrantal couple only.

Our mode of working will be seen from Fig. 9. The hanging sphere, 0.9 cm. in diameter and 1 gm. in weight, was placed in a light aluminium wire cage with a mirror on it, and suspended by a long quartz fiber in a brass case with a window in it opposite the mirror, and surrounded by a double-walled, tinfoiled wood case. The position of the sphere was read in the usual way, by scale and telescope. The time of swing of this little sphere was one hundred and twenty seconds.

A larger quartz sphere, 6.6 cm. diameter and weighing 400 gms., was fixed at the lower end of an axis, which could be turned at any desired rate by a regulated motor. The centers of the spheres were on the same level and 5.9 cm. apart. On the top of the axis was a wheel with 20 equidistant marks on its rim, one passing a fixed point every eleven and five-tenths seconds.

It might be expected that the couple, if it existed, would have the greatest effect if its period exactly coincided with the one hundred and twenty second period of the hanging sphere, i. e., if the larger sphere revolved in two hundred and forty seconds; but in the conditions of the experiment the variations of the small sphere were very much damped, and the forced oscillations did not mount up as they would in a freer swing. The disturbances, which were mostly of an impulsive kind, continually set the hanging sphere into large vibration, and these might easily be taken as due to the revolving sphere. In fact, looking for the couple with exactly coincident periods would be something like trying to find if a fork set the air in a resonating jar vibrating when a brass band was playing all round it. It was necessary to make the couple period, then, a little different from the natural one hundred and twenty second period, and accordingly we revolved the large sphere once in two hundred and thirty seconds, when the supposed quadrantal couple would have a period of one hundred and fifteen seconds.

Figs. 10 and 11 may help to show how this enabled us to eliminate the disturbances. Let the ordinates of the curves in Fig. 10 represent vibrations set out to a horizontal time scale. The upper curve is a regular vibration of range $\pm$ 3, the lower a disturbance beginning with range $\pm$ 10. The first has period 1, the second period 1.25. Now, cutting the curves into lengths equal to the period of the shorter time of vibration and arranging the lengths one under the other, as in Fig. 11, it will be seen that the maxima and the minima of the regular vibration always fall at the same points, so that, taking 7 periods and adding up the ordinates, we get 7 times the range, viz., $\pm$ 21. But in the disturbance the maxima and minima fall at different points, and even with 7 periods only, the range is from + 16 to — 13, or less than the range due to the addition of the much smaller regulation vibration.

In our experiment the couple, if it existed, would very soon establish its vibration, which would always be there and would go through all its values in one hundred and fifteen seconds. An observer, watching the wheel at the top of the revolving axis, gave the time signals every eleven and five-tenths seconds, regulating the speed if necessary, and an observer at the telescope gave the scale reading at every signal—that is, 10 times during the period. The values were arranged in 10 columns, each horizontal line giving the readings of a period. The experiment was carried on for about two and one-half hours at a time, covering, say, 80 periods. On adding up the columns the maxima and minima of the couple effect would always fall in the same two columns, and so the addition would give 80 times the swing, while the maxima and minima of the natural swings due to disturbances would fall in different columns, and so, in the long run, neutralize each other. The results of different days' work might, of course, be added together.

There always was a small outstanding effect, such as would be produced by a quadrantal couple, but its effect was not always in the same columns, and the net result of about three hundred and fifty period observations was that there was no one hundred and fifteen second vibration of more than 1 second of arc, while the disturbances were sometimes 50 times as great.

The semicircular couple required the turning sphere to revolve in one hundred and fifteen seconds. Here want of symmetry in the apparatus would come in with the same effect as the couple sought, and the outstanding result was accordingly a little larger.

But in neither case could the experiments be taken as showing a real couple. They only showed that, if it existed, it was incapable of producing an effect greater than that observed.

Perhaps the best way to put the result of our work is this: Imagine the small sphere set with its axis at 45 deg. to that of the other. Then the couple is not greater than one which would take five and one-fourth hours to turn it through that 45 deg. to the parallel position, and it would oscillate about that position in not less than twenty-one hours.

The semicircular couple is not greater than one which would turn from crossed to parallel position in four and one-half hours, and it would oscillate about that position in not less than seventeen hours.

Or, if the gravitation is less in the crossed than in the parallel position, and in a constant ratio, the difference is less than 1 in 16,000 in the one case and less than 1 in 2,800 in the other.

We may compare with these numbers the difference of rate of travel of yellow light through a quartz crystal along the axis and perpendicular to it. That difference is of quite another order, being about 1 in 170.

As to other possible qualities of gravitation, I shall only mention that quite indecisive experiments have been made to seek for an alternation of mass on chemical combination,* and that at present there is no reason to suppose that temperature affects gravitation. Indeed, as to temperature effect, the agreement of weight methods and volume methods of measuring expansion with rise of temperature is good, as far as it goes, in showing that weight is independent of temperature.

So, while the experiments to determine G are converging on the same value, the attempts to show that, under certain conditions, it may not be constant, have resulted so far in failure all along the line. No attack on gravitation has succeeded in showing that it is related to anything but the masses of the attracting and the attracted bodies. It appears to have no relation to physical or chemical condition of the acting masses or to the intervening medium.

Perhaps we have been led astray by false analogies in some of our questions. Some of the qualities we have sought and failed to find, qualities which characterize electric and magnetic forces, may be due to the polarity, the + and —, which we ascribe to poles and charges, and which have no counterpart in mass.

But this unlikeness, this independence of gravitation of any quality but mass, bars the way to any explanation of its nature.

The dependence of electric forces on the medium, one of Faraday's grand discoveries forever associated with the Royal Institution, was the first step which led on to the electromagnetic theory of light now so splendidly illustrated by Hertz's electromagnetic waves. The quantitative laws of electrolysis, again due to Faraday, are leading, I believe, to the identification of electrification and chemical separation—to the identification of electric with chemical energy.

But gravitation still stands alone. The isolation which Faraday sought to break down is still complete. Yet the work I have been describing is not all failure. We at least know something in knowing what qualities gravitation does not possess, and when the time shall come for explanation all these laborious and, at first sight, useless experiments will take their place in the foundation on which that explanation will be built.

VOYAGES OF THE ICE-BREAKER "ERMACK."

MR. ARTHUR GULSTON recently delivered a lecture before the Institute of Marine Engineers in London upon the "Baltic and Arctic Voyages of the 'Ermack.'" Mr. Gulston in his opening said that ice breakers were in existence as far back as the year 1870, the first being a converted tug at Cronstadt. It was, however, only during the last twenty years that they had reached large dimensions. The "Ermack," built by Sir W. G. Armstrong, Whitworth & Co., is 335 feet in length, 71 feet beam, and with her coals and stores on board has a displacement of about 8,000 tons. Her propelling machinery consists of four sets of triple-expansion engines of 2,500 horse power each, steam being generated in six very large double-ended boilers that were built for 160 pounds pressure. The "Ermack" is capable at half power of putting 1,300 tons of weight on the ice to crush it down, when in her ordinary ice-breaking trim, with a draft of 22 to 23 feet. The bow is enormously strong, and for a considerable distance the frames are only 12 inches apart. The ice-belt at the bow extends to the keel and at the sides of the ship it is 27 feet deep. The "Ermack" left the Tyne on her maiden voyage to Cronstadt early in March, 1899, under the command of Capt. Vassilieff, Admiral Makaroff of the Russian navy being also on board. In less than a fortnight after sailing the ice-blink was seen just before dark, the first drift-ice being met with off the western end of the harbor of Revel. In the Gulf of Finland the small drift ice is first met, this gradually grows to a paste, which, in calm weather, soon solidifies into floes. These latter get larger until the solid ice is met, and it is in this that the packs of ice are found. The "Ermack" proceeded by night through the ice, which was illuminated by the electric projector. On the rocks and islands in the Gulf of Finland the ice forms to an enormous thickness, and the noise occasioned at the bow of the vessel when breaking ice was considerable; but, such is use, after the first day it was scarcely noticed, and the vibration set up forward was very small. The "Ermack" pursued her way through the ice right up to Cronstadt, the entrance of the ship into that port being the occasion of great excitement, as up to the time of her arrival it had been firmly predicted that the feat was an impossibility. Below Cronstadt the vessel could easily break her way through the ice at 8 knots an hour, the ice-field being from 18 inches to 24 inches thick, with 6 inches of snow upon it. Three days after her arrival at Cronstadt she was ordered to Reval to save steamers that were in danger of being crushed by the ice, and to open the port. Upon arrival at Revel bay it was found that an enormous ice-pack had been formed across the entrance to the bay, 15 miles from the town of Reval. The pack had formed during a northwest gale that had blown the drift-ice from the Baltic into the bay, packing it 3½ miles across, about one-third of a mile wide, and from 20 feet to 25 feet thick, completely closing the harbor. In two hours the "Ermack" succeeded in crushing a way through this ice-pack, which achievement had necessitated fourteen charges, the newly-fallen snow being a great obstruction. During the limited time that the "Ermack" was on that station she was in-

* Physical Review, V, 1897, p. 294.

† Physical Review, II, 1895, p. 321.

‡ Phil. Trans. 192, 1899, A, p. 245.

* Landolt, Zeit. für Phys. Chem., XII., 1, 1894. Sanford and Ray, Physical Review, V, 1897, p. 247.

strumental in salving eighty-two vessels that were fast in the ice. The lecturer then proceeded to give an account of the Arctic voyage of the "Ermack," the object of that expedition being to test the capabilities of large ice-breakers among the polar ice. On the Arctic trip the "Ermack" left the Tyne on July 23, 1899, and proceeded to Advent Bay, in Ice Fjord, Spitzbergen. She was fully provisioned for twelve months. Advent Bay was left on August 5, and on the following day they encountered the first polar drift-ice. Then the fight began in real earnest, collisions with enormous masses of ice occurring continually. The floes became thicker and older as they proceeded north, and it was soon a question of ice breaking and charging all the time. In speaking of charging it must be understood that the vessel, when stopped by ice, retired 100 yards or more, got up speed to strike the strong spot, and continued to do so until the obstruction was broken down. The "Ermack" was also designed for charging astern when desirable. In some of the water lanes it was strange to note how the ice had separated in a vertical cleavage, leaving the walls of solid ice on each side of the canal from 12 feet to 20 feet thick. With half boiler power the "Ermack" could force her way through polar ice 12 feet to 14 feet thick at 2½ to 3 knots an hour.

TRADE SUGGESTIONS FROM UNITED STATES CONSULS.

Agricultural Implements in South Germany.—Not only are American mowers, harvesters, and hayrakes in use in all the farming districts of South Germany, but our smaller agricultural implements, such as forks, garden and lawn rakes, hoes, shovels, spades, and hand potato diggers, have also rapidly grown in favor and are now on sale in nearly every local hardware store. The lighter construction and better shape of American tools are conceded; and here in Germany, where so much of the farm work is done by hand, these articles should continue to find a ready market.

I have never seen in this district any of the convenient apparatus commonly employed in the United States for spraying fruit trees, vines, and other vegetation. The sprayers in use are primitive in construction, consisting essentially of a watering can, with hose and nozzle attached, carried by the operator, the weight of the water furnishing the pressure. American spraying pumps and other similar apparatus should be in demand.

As is well known, Germany produces vast quantities of potatoes and is coming more and more to depend upon this crop. They are frequently grown over large areas and are for the most part planted and dug by hand, the latter operation being assisted by means of an ordinary plow. An American engaged in selling harvesters in Germany informs me that he has had several inquiries as to the prices and efficiency of the potato planters and diggers used in the United States. He is of the opinion that in some of the territory over which he has traveled, American planters and diggers, drawn by horses, could probably be sold in paying quantities.

The same gentleman says that he has had frequent inquiries as to windmills for pumping water and operating small feed grinders. Such windmills are rarely seen in this part of Germany. In view of the fact that most of the farmers live in villages, it is not probable that the mills would come into such general use as in most parts of the United States. The field, however, would seem to invite the attention of manufacturers who have agencies for these mills in other parts of Europe.

Weighing scales of the convenient forms employed in warehouses, freight houses, groceries, mills, etc., are not in use here. In this class of appliances there would seem to be an opening for our manufacturers.

In making tools and implements for the German trade, it should not be forgotten that durability is a greater virtue in Germany than it is in the United States. Tools frequently go into unskillful hands, and a degree of heaviness is not so objectionable as are breakage and need of frequent repairs. The wood used in handles should be well selected, and the parts subjected to special strain made strong.—H. W. Harris, Consul at Mannheim.

Trade Conditions in Wurttemberg.—Notwithstanding the prevailing commercial depression, 1902 showed a slight improvement over the preceding year, in that many factories which were obliged to curtail greatly their force in 1901 have re-employed the workmen and striven sturdily to maintain a fitting place in the world of trade. With a rising market for raw materials and a falling market for their products, the lot of the German manufacturer has, generally speaking, been a troubled one. It will probably be some time before confidence is restored. There seems to be a general feeling of doubt regarding the effects of the new tariff law.

Musical Instruments.—The chief musical instrument exported from Wurttemberg is the harmonica, which is sold in greater quantities in the United States than in any other country. There are several large factories in neighboring smaller towns. One concern has one main factory and 15 branches in which are employed 1,500 hands. Much of the work is done at home by the employes. The annual output of this one concern has for several years past been about 5,000,000 harmonicas. Competition in this line is extremely keen and goods are often sold for unusually small profits in order to hold the trade. The firms ship direct to all their customers in nearly every country in the world. It is said that the harmonica manufacturers intend to send an exhibit to the St. Louis Exhibition.

The Piano Industry.—The piano industry of Stuttgart, so well known in Europe, has been less satisfactory than in former years, exports decreasing about 400 tons; but, nevertheless, the three large firms here had enough work to keep their mills going full time. The loss of trade by this industry was felt more in northern Germany than in Wurttemberg. In fact, one local firm reports that it did more business last year than ever before, and trade was better in both the domestic and foreign markets. In Russia, Spain, Central and South America, and South Africa business was bad, but later the outlook for Mexico improved. No pianos are sold to the United States on account of the high tariff, but there is keen competition with American manufacturers in Mexico and Central and South America.

The exports of pianos during the last three years were:

	Tons.
1900	12,185.2
1901	12,706.5
1902	12,324.7

Surgical Instruments.—This is quite an industry in this district, and one of the largest surgical-instrument factories in the world is located here. It produces over 20,000 different instruments for human and animal surgery. While the trade has shown considerable improvement over that of the past two years, profits have been much curtailed by aggressive competition and increased cost of raw material. The outlook for 1903 is believed to be very good, except for business with the United States, where the tariff, it is said, prohibits increased trade.

Furniture.—The manufacture of fine furniture is one of the chief industries of Stuttgart. The cheaper grades are also made here and in many of the small towns of the Kingdom.

A fair is held here every May and December, where cheap handmade furniture is exhibited, made chiefly by the small manufacturers in the towns. This kind of furniture is neither as cheap nor as comely as that of the same grade made in the United States, and there appears to be a field here for American goods of this class, if it is properly cultivated. There is no furniture of any kind sent from Wurttemberg to the United States. Some English furniture of good quality is sold here. The trade in general shows a very marked improvement, and the outlook is good.

American office furniture is on sale in Stuttgart, but our manufacturers fail to seize the opportunity to push their goods and frequently allow the Germans, with their goods made closely after American patterns, to get ahead of them in the field of active competition. The result is that domestic imitations of nearly all office furniture are at least as well established as the genuine American articles. They do not have quite the fine appearance of the goods which come from the United States, but customers do not seem to be as critical here as elsewhere; and, besides, the fact that an article is of German manufacture often appeals to the buyer more strongly than does superiority of finish and form. Patriotism is not to be lost sight of in international trading.

American Tools and Machinery.—About the only American tools sold in this district are those found chiefly in iron foundries and large machine shops. Our agricultural machinery, owing to the smallness of the farms, has little demand.

American small tools are not pushed in this market; but American novelties and kitchen utensils are well liked and are in good demand. They are bought chiefly in Hamburg.

A factory supplied entirely with American machinery for making broom and brush handles has within the past three months been established by American capital in a village in this district. I am informed that it already has on hand contracts for the entire year's output.

Dry Goods.—Business in this line in the past year has improved. Unfortunately, however, Americans are not offering their goods in this market. Dealers here inform me that they could find plenty of trade for American goods, if our manufacturers would seriously compete for business and quote prices with freight and duty paid. By a generous distribution of dry-goods journals, I have succeeded during the past year in arousing interest in American styles and manufactures. Several of the largest German shops have subscribed to some of these periodicals.

English and French importations are decreasing yearly, as German manufacturers are learning to imitate, in a more or less satisfactory manner, the articles heretofore purchased in large quantities from these countries. American thread and silks should be sold here, but do not seem to be offered steadily.

Toys.—Business in this line was satisfactory—considerably better than in 1901. Prices for raw materials reached the normal and were steady. Profits were consequently greater than in former years, when prices fluctuated wildly. Even the home market has been good; but manufacturers prefer to have a few first-class customers in the United States and to keep them well supplied, rather than to increase their sales to uncertain buyers. Competition is increasing and buyers require longer terms for payment. In the United States and Germany, the demand is growing for complicated toys of a novel character. The outlook is good.

American Shoes.—Neglect of this market continues. A few shoes of American make are sold to those who especially want them, but there is no effort to push their sale. One or two dealers handle them, but more for the purpose of exploiting the imitation German foot wear than for regular sale. The German manufacturer more nearly each year reaches the finish and general appearance of the American shoe. He has not arrived at the goal yet, but is well on the way, and his success so far is due in part to the failure of the American manufacturer to push his trade in this country. There is still time for him to enter this market seriously, but he should do it at once. I am told that there are fewer American shoes sold now than in the past few years; but this is not to be wondered at, as absolutely no effort is made, in this district at least, to do anything toward capturing the fine trade that certainly exists for those who have the enterprise to work it up.

Bicycles.—There is one large manufactory in this district that employs about 500 hands. It reports a very satisfactory business—an increase of 25 per cent over last year. Competition on the part of American wheels is decreasing steadily, owing to the fact that a few years ago numbers of cheap American machines were thrown upon this market. They proved most unsatisfactory. As a result, people lost confidence in them, and, with the exception of a few of high grade which still find a limited sale, there are no American bicycles now sold in this district.

Jewelry.—The manufacturers of jewelry in this district have only recently begun to turn their attention to the United States as a field of export, although the neighboring country of Baden has for many years sold largely not only to the United States, but also to Porto Rico and Cuba.

About six months ago, a large manufacturer of jewelry in this district sent a member of the firm to the United States to study the market. He took along with him a fine line of samples and succeeded in selling about $6,000 worth of goods. He considers these sales as merely sample orders, and expects to do a very satisfactory business in the near future. The firm has come to the conclusion that there is no market in the United States for cheap German jewelry, as the manufacturers there have better machinery; but on the other hand, it believes that the American manufacturer of jewelry can not compete with the European in the markets of Europe. This firm expects to sell the finer grades in the United States, and realizes that it can be successful only by closely studying American tastes and conforming to American ways of doing business.

Both the English and the domestic market have been dull in the last twelve months, and no great revival is expected for this year. It is thought, however, that the worst is over and trade will gradually recover. The orders received late in the autumn indicate that the feeling is better.

Leather.—About the only leather exported from this district is that used for rollers in large printing presses. This industry increased its exports to the United States nearly 40 per cent last year.

The manufacturers of high grade sole and belt leather report that business has been unsatisfactory, owing to a rise in the price of raw material, especially in the latter half of the year. The outlook is said to be gloomy.

Watchmen's Detectors.—The business is in the hands of one firm, which exports largely to the United States, nearly every State in the Union supplying customers for this product. The export trade with America increased about 20 per cent and its outlook for the future is bright.

Carbolineum.—Carbolineum, a patent wood preserver, is manufactured largely in this district and exported to many parts of the United States, particularly the West and South. There is also a good business with England. The trade, particularly in the domestic market, has been unsatisfactory in the last year and the outlook is not promising.

Machine Needles.—This industry, after a lapse of several years, has again made its appearance in the trade with America. No needles of the cheaper grades, however, can be exported from here with profit, as American manufacturers can produce them at less cost. It is the high-priced article that meets with keen competition from this country, and local manufacturers did a most satisfactory business last year. The outlook for future trade is good.

Manufacturers claim to have not only the very latest machinery for producing needles, but also cheap labor. Knitting-machine needles are now quoted here at an average of 28 marks ($6.66) per thousand, and round stool needles at 6 marks ($1.43).—Edward H. Ozmun, Consul at Stuttgart.

British Inquiry for Steel Castings.—Consul Marshal Halstead, of Birmingham, March 24, 1903, says that a manufacturer of anchors wishes to be put into communication with the makers of large steel castings and forgings. He wishes to hear from manufacturers who are able to take orders for and make early deliveries.

Demand for Dried Fruits in France.—Consul B. H. Ridgely writes from Nantes, March 6, 1903, that a responsible commission merchant of that city desires to correspond with American exporters of dried fruits, particularly dried apples, and of sulphate of copper. Communications should be addressed to M. Maximo Boquien, care United States consulate, Nantes.

Opening for American Machinery in South Africa.—Consular Agent W. D. Gordon, of Johannesburg, informs the Department, February 7, 1903, that he has received inquiries for machinery for cleaning and preparing for the market corn, tapioca, beans, and peanuts, and requests manufacturers in the United States to send him catalogues and data.

Waterworks for Guayaquil.—Vice-Consul R. B. Jones reports from Guayaquil, March 19, 1903, that Señor L. Garcia, of that city, has sailed for New York to make arrangements for the construction of a system of sewers, firemains, and pumping station for Guayaquil. Señor Garcia will remain in New York about two weeks, and can be seen through W. R. Grace & Co., or G. Amsinck & Co. As he takes with him all the necessary data, Mr. Jones suggests that it would be well for American capitalists to bid on this contract. Funds for the work have been provided by the imposition of an export duty on cocoa.

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SELECTED FORMULÆ.

Washing Powder.—

I.

Hard soap	5 parts
Soda ash	3 parts
Sodium silicate	2 parts
Borax	1 part

II.

Hard soap	4 parts
Sal soda	3 parts
Sodium silicate	2 parts

—Drug. Circular.

Salicylic Acid Corn Cure.—

Extract cannabis indica	1 part
Salicylic acid	10 parts
Oil of turpentine	5 parts
Acetic acid, glacial	2 parts
Cocaine, alkaloidal	2 parts
Collodion, elastic, sufficient to make	100 parts

Directions for use: Apply a thin coating every night, putting each layer directly on the preceding one. After a few applications, the mass drops off, bringing the indurated portion, and frequently the whole of the corn, off with it.—National Druggist.

Violet Smelling Salt.—I. Moisten coarsely powdered ammonium carbonate with a mixture of

Strong tincture of orris root	2½ ounces
Extract of violet	3 drachms
Spirit of ammonia	1 drachm

II. Fill suitable bottles with coarsely powdered ammonium carbonate, and add to the salt as much of the following solution as it will absorb:

Oil of orris	5 minims
Oil of lavender flowers	10 minims
Extract of violet	30 minims
Stronger water of ammonia	2 ounces

—Drug. Circular.

Indelible Ink.—The following formula is said to be used largely in one of our public institutions for marking linen, etc:

1. Silver nitrate	1 ounce
Stronger ammonia water	4 fl. ounces
Potassium bitartrate	1 ounce
Powdered sugar	1 ounce

Dissolve the silver nitrate in the stronger ammonia water, then add the cream tartar and sugar and shake the mixture until solution is effected.

2. Powdered acacia	3½ fl. ounces
Lampblack	40 grains

For use mix about equal quantities of the preceding solution (a) and mixture (b) on a slab and apply by means of a stencil. The fabrics must be afterward heated or passed over with a hot iron to make the marks lasting.—Pharmaceutical Era.

Shoe Blacking.—

Ivory black	2 pounds
Sperm oil	4 ounces
Molasses	1 pound
Vinegar	5 ounces
Strong sulphuric acid	4 ounces
Sulphate of iron	4 drachms
Gum arabic	6 drachms
Hot water	5 ounces

Mix the black, sperm oil, molasses, and vinegar together in the order named, and gradually add the sulphuric acid. Heat, if necessary, until effervescence ceases; then add the iron and gum arabic previously dissolved in the hot water.—Pharm. Era.

Cleaning Powder.—

Bole	500 parts
Magnesium carbonate	50 parts

Mix and make into a paste with a small quantity of benzin or water; apply to stains made by fats or oils on the clothing and when dry remove with a brush.—Pharm. Era.

Table Sauce.—Brown sugar, 16 parts; tamarinds, 16 parts; onions, 4 parts; powdered ginger, 4 parts; salt, 4 parts; garlic, 2 parts; cayenne, 2 parts; soy, 2 parts; ripe apples, 64 parts; mustard powder, 2 parts; curry powder, 1 part; vinegar, q. s. Pare and core the apples, boil them in sufficient vinegar with the tamarinds and raisins until soft, then pulp through a fine sieve. Pound the onions and garlic in a mortar and add the pulp to that of the apples. Then add the other ingredients and vinegar, 60 parts; heat to boiling, cool, and add sherry wine, 10 parts, and enough vinegar to make the sauce just pourable. If a sweet sauce is desired add sufficient treacle before the final boiling.—Pharm. Era.

Blackboard Paint.—

Shellac	4 ounces
Lampblack	2 ounces
Emery, powdered	1 ounce
Ultramarine	1 ounce
Alcohol	40 ounces

Dissolve the shellac in the alcohol; place the lampblack, emery, and shellac on a cheesecloth strainer, pour on part of the shellac solution, stirring constantly, gradually adding the rest of the solution until all of the powders have passed through.—Pharm. Era.

Egg Powder.—

Sodium bicarbonate	8 ounces
Tartaric acid	3 ounces
Cream tartar	5 ounces
Tumeric, powdered	3 drachms
Ground rice	10 ounces

Mix and pass through a fine sieve. One teaspoonful to a dessertspoonful (according to article to be made), to be mixed with each half pound of flour.

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